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THE RESTORATION OF DUNN POND

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Cover photograph: view of Dunn Pond from the southeastern cove six years after completion of the restoration project.
Photo credit: Robert C. Haynes

SECTION 314 PHASE II RESTORATION PROJECT OF DUNN POND

IN

GARDNER, MASSACHUSETTS

by

Robert C. Haynes, Ph.D.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection
Division of Water Pollution Control
Limnology Group
Boston, Massachusetts

Executive Office of Environmental Affairs
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AUTHOR: **Robert C. Haynes, Ph.D.**

REVIEWED BY:

Richard S. McVoy 3/31/94

Richard S. McVoy, Ph.D.
Manager, Limnology Group

APPROVED BY:

Russell A. Isaac 3/31/94

Russell A. Isaac, Ph.D., P. E.
Assistant Chief Engineer

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The depth contours shown in Fig. 3 were derived from the Final Grading Plan of Dunn Pond, which was developed by Pharmer Engineering Corporation of Holyoke, Massachusetts, and kindly provided to me by Charles Swanson. Figure 4 was modified from Huntington et al. (1981), and Figs. 5, 6, and 7 were modified from Gardner/DEM (1982).

EXECUTIVE SUMMARY

This final report is documentation of the Section 314 Phase II Restoration Project of Dunn Pond, which is located in north central Massachusetts within the corporate limits of the City of Gardner. Historically, the natural beauty of this park pond and its close proximity to the city made it a favorite spot for active and passive recreation. By the late 1970's, however, this "...beautiful sheet of water..." had become characterized by "...urban storm water, dump leachate, and sewer overflows...," and it was "...shallow, muck floored, and weed infested." Storm water runoff flowed into the pond from a network of drain pipes covering about 105 acres, more than five times the pond's surface area. Human disturbance of vegetation along the steep slopes of the park surrounding the pond further exacerbated the sedimentation problem. In 1980 the average pond depth was estimated at only 3 feet by the Massachusetts Division of Fisheries and Wildlife, and 60% of the pond's surface area was covered with emergent vegetation. It was indeed fortuitous for Gardner that the degraded condition of Dunn Pond coincided with enactment of both federal and state legislation developed in the late 1970's and early 1980's to address the widespread eutrophication of lakes and ponds. Similarly, the degraded condition of Dunn Park coincided with enactment of state legislation facilitating the establishment of urban state parks, as noted below.

In 1978 the Massachusetts Department of Environmental Management (DEM) and the Office of State Planning issued requests for proposals for urban heritage state parks. Gardner submitted a successful proposal and portions of the city, including Dunn Park/Dunn Pond, were designated as Gardner Heritage State Park on November 1st of that year. The City's plan was to restore center-city sites and to connect them to Dunn Park through a 1.25 mile corridor. Storch Associates of Boston was contracted by DEM to develop preliminary and final design plans for these sites. Baystate Environmental Consultants, Inc. of East Longmeadow, Massachusetts, developed the Phase II application for funding the restoration of Dunn Pond. This firm also completed environmental studies and design plans as a subcontractor to Storch Associates. On February 4, 1981 U. S. EPA Region I approved a financial assistance agreement in the amount of $625,000 with the Department of Environmental Quality Engineering (subsequently renamed Environmental Protection) for its share of the Dunn Pond restoration project. The non-federal share of the total project cost was derived from the Commonwealth's Chapter 628 Clean Lakes and Great Ponds Program ($337.170.74) and Chapter 798 Urban Heritage State Park funds ($307.110.26).

Major work elements of the Phase II project at Dunn Pond included final design specifications and engineering documents, excavation and disposal of sediments, construction of a filter dike in Stump Pond to retain suspended solids and to reduce the concentration of total phosphorus, and diversion of storm water to Stump Pond. It is noted here that the latter pond was part of, and is hydraulically connected to, Dunn Pond via culverts under a constructed roadway (Pearl Street) that severed this "cove" from the main body of water. Other related tasks included reconstruction of the culverts connecting the two ponds, removal of spoils from a previously constructed interceptor sewer, and removal of 6293 cubic meters of material from a late 19th - early 20th century dump on the east shore of Stump Pond. Restoration of Dunn Pond was undertaken in a sequential series of construction tasks performed by Pacella Brothers, Inc., of Plainville, Massachusetts. The actual expenditure of funds to complete this project was $1,263,891.26; the federal share of that amount was $619,610.26. Since a large volume (220,362 cubic yards) of sediment and peat was excavated from Dunn Pond, the per-unit-volume cost of $3.15 per cubic meter ($2.40/cubic yard) was comparatively low.

The contractor began excavating Dunn Pond on January 7th, 1984, and all construction work was completed on March 4th, 1985. Refilling of the two ponds officially began on March 6th and normal pool level was established in early April. Final inspection of this project site by personnel representing federal, state, and city agencies as well as respective consultants and the contractor occurred on May 17th. For a variety of reasons Pacella Brothers, Inc. were not able to meet contract deadlines. Among these reasons were 54 work days lost to inclement weather, 25 calendar days lost to a work stop order, and additional time lost during project change orders. Also, the pooling of subsurface and ground water near the deepest point of sediment removal was a persistent problem. The date of completion of all construction work was one year beyond the original contract limit of 180 days.

The DEP's Division of Water Pollution Control managed this restoration project, including seven years of pre-, post-, and construction monitoring. Most evident among pre-construction data is the poorly buffered, acidic natural drainage to Stump Pond and, subsequently, Dunn Pond. The pH range (4.0 to 4.5 units) of tributaries attests to the acidity of this water and to the high concentration of dissolved organic acids characteristic of this drainage. There are no immediate pre-construction data for Dunn Pond *per se* since it had been drained to construct an interceptor sewer prior to this project. The discussion of construction phase data is focused on the discharge of suspended solids to Foster Brook during excavation of Dunn Pond when the sediment trap, erected by the contractor, proved to be inadequate. Although there is no apparent record of the severity of

that discharge, a stop order was issued to halt further construction until this problem was resolved. The contractor was eventually required to excavate a forebay settling pond and erect a course rock berm filter near the outlet to mitigate any further impacts to Foster Brook. A supplemental monitoring program was initiated to record discharges of suspended solids and to measure turbidity at the outlet of Dunn Pond as well as along Foster Brook. An analysis of these data reveals that suspended solids did not exceed 25 mg/L at the outlet, and the maximum turbidity was only 21 Jackson Turbidity Units. These and other data indicate possible, but quite limited, violations of Massachusetts Water Quality Standards, and only at stations proximal to the construction site. Thus, in general, the mitigation plan was successful.

Analysis of the post-construction data reveals that diversion of storm water to Stump Pond does protect Dunn Pond from heavy loads of sediment and phosphorus. The large sand/silt bars in Stump Pond that extend outward from both drain pipes attests to this fact. It is evident from a comparison of mean concentrations of total suspended solids measured on either side of the filter dike (4.0 and 2.5 mg/L, respectively) that smaller suspended particles are removed as well. The cross-dike differences in total phosphorus (70 μg/L and 40 μg/L) were substantially different also, indicating that this nutrient does bind to materials used to construct the dike as stormwater percolates through this structure. Despite these observed successes, Stump Pond is not performing as designed since a portion of stormwater apparently bypasses this detention and filtration system by way of a small, vertical pipe spillway. The stop logs within this structure are apparently not set to the proper elevation (1106.0 feet MSL), perhaps as a consequence of vandalism.

A rather thorough discussion of the limnology of Dunn Pond is presented in this final report since the restored body of water is significantly different from its predecessor. Included in this discussion are pond morphometry, thermal regime, hydrochemistry, macrophytes, phytoplankton, and fish. The high concentration of organic acids not only imparts a tea color to the water of this pond, it also exhibits a strong influence on all the aforementioned features except morphometry. These peculiarities do not interfere with the pursuit of recreation, however, since the new park and pond have become especially attractive to urban residents of Gardner. Attendance has increased 230% since 1987, an increase largely attributable to the fact that Dunn Pond now sustains multiple uses including sport and pan fishing, swimming, boating (without motors), skating, and even log rolling. Fishing derbies typically draw 600 to 1000 people, depending on weather, and about 500 people participated in a skating party held during the winter.

Dunn Pond is an exemplary restoration project for many reasons, and foremost among these is the vastly improved condition of the pond. Its cold water fish habitat, stocked with brook trout, is a sterling example. It is exemplary also because the problems that led to its degraded condition have been addressed and corrected. This scenic and aesthetically pleasing "...jewel in the landscape..." is located just 1.25 miles from the center of Gardner, which renders its restoration even more commendable. And, it now sustains a wide variety of recreational activities on a year-round basis. Its conversion from a city park pond to a state park pond will likely assure the longevity of this restoration program.

The cooperation of federal, state, and city agencies as well as private consultants was paramount to the success of this project. Also, the total expenditure of funds to complete this work was not extraordinary given the extent of the restoration work, the quality of the pond, and the long-term prospects for the pond to sustain more varied an more intensive use by the public. Since the proper and timely maintenance of structures erected in Stump Pond are essential to protect the water quality of Dunn Pond, the Department of Environmental Management needs to acquire the Stump Pond property from the City of Gardner. And, specific recommendations for managing Dunn Pond and Stump Pond are included in Appendix XI of this report.

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INTRODUCTION

"In the spring of 1896 Mr. [John Ainsworth] Dunn purchased of the Charles Heywood heirs, thirty-five acres of land lying between Pearl Street and the old Westminster Road; of the Morrill estate seven acres, and of the Howe heirs thirty-five acres, which, with additions since made, he proposes to give to the town [Gardner] for a public park. This land skirts the charming Betty Spring Road, and includes some of the most beautiful wooded land in Gardner. It comprises a sweep of grassy meadow, an area of rough and wild territory, and a lake to be made out of the meadow where the brook [Foster Brook] runs through it, thus including within its limits a variety of natural scenery." The preceding quotation was from Cary (1908), although the same information can be found in a newspaper article titled "A Public Park. John A. Dunn's munificent gift to Gardner" published in the May 2, 1896 issue of the Gardner News. Three years later the Gardner News also featured an article titled "A Beautiful Park for Gardner" in its May 18, 1899 issue. It is stated in this article that "the plans of Mr. Dunn include, at some time, the damming of the stream [Foster Brook] to form a lake. The laying of the land makes the scheme thoroughly feasible in each detail. A beautiful sheet of water about half as large as Crystal Lake would be the result." This was indeed a feasible scheme, primarily because a shallow, post-glacial kettlehole lake occupied this very site before it eventually "succeeded to a wooded wetland" (Anon. 1981).

Mr. Dunn generously opened his "park and pleasure ground" to the general public in September 1896, although title to the park property was not transferred to Gardner until after his death in 1919. Archived material kept by the Levi Heywood Memorial Library in Gardner (personal communication with David Fournier) does not reveal whether Mr. Dunn had dammed Foster Brook to create a body of water prior to his death. However, it is evident from a January 25, 1934 drawing by City Engineer Sig. Kendal (Baystate 1980) that a small body of water existed in this City-owned park and that its area was limited to four acres. Based on his 1934 drawings, Kendal's plan was to increase the size of the park pond to approximately twenty (20) acres. Undoubtedly, Kendal's plan was put into effect, since a "rolled earthfill dam with a one foot thick concrete core wall in the center" was constructed by the Works Program Administration in 1934 (Storch Associates 1981). Thus, Dunn Pond was formed.

Situated in north central Massachusetts (Fig. 1), at the drainage divide between the Merrimack River Basin to the east and the Connecticut River Basin to the west, Gardner today is a city of approximately 19,000 residents. Dunn Park/Pond is located about 1.25 miles northeast of the City center, within the

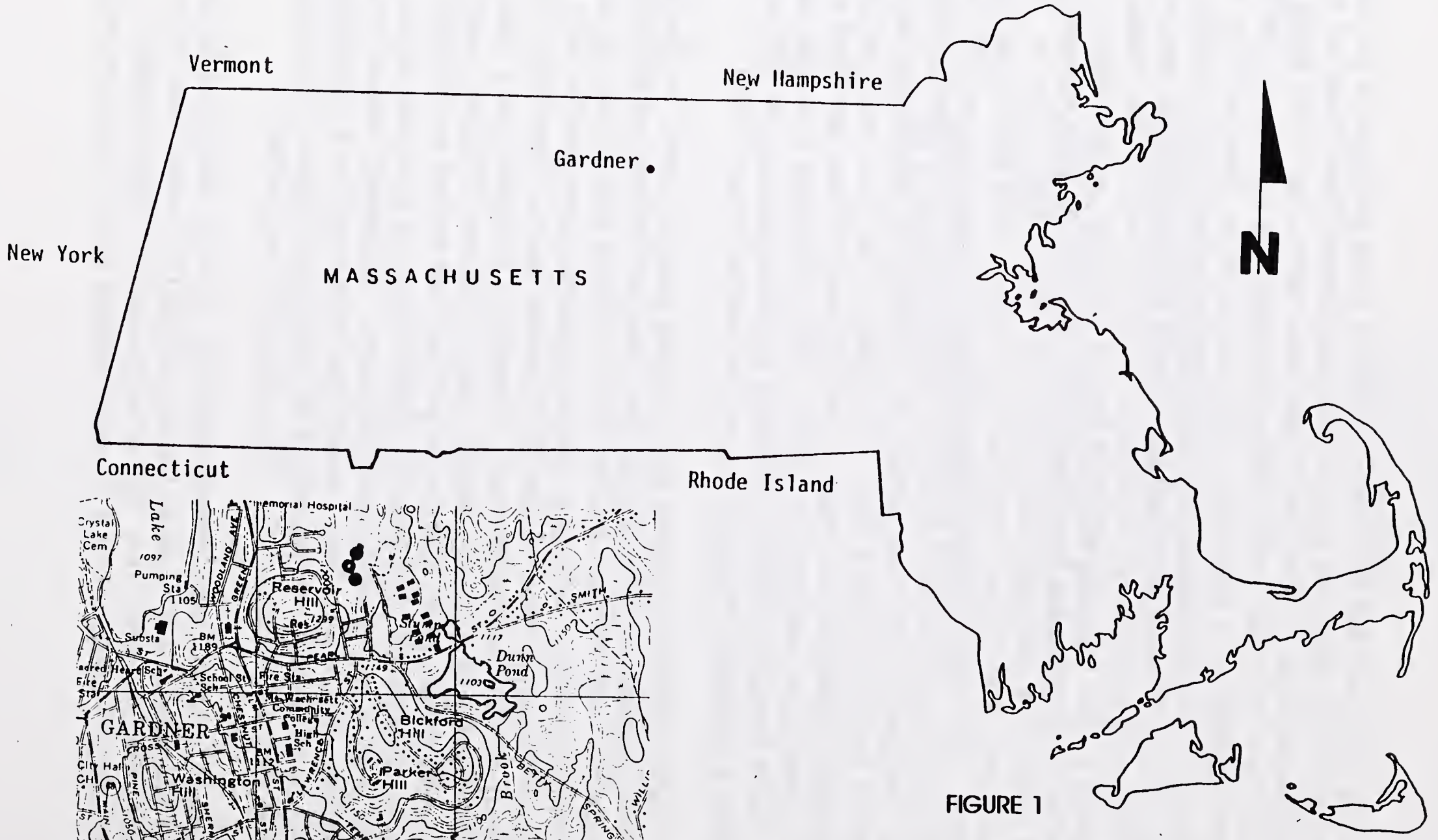


FIGURE 1

LOCATION OF PROJECT SITE IN GARDNER, MASSACHUSETTS.

corporate limits of Gardner and adjacent to Pearl Street, or Route 101. North of Dunn Pond, Foster Brook rises in a 500 acre tributary drainage area that is a headwater to the Connecticut River. Foster Brook discharges to Stump Pond (see Station 4 on Fig. 2), a 2 acre impoundment that is hydraulically connected to Dunn Pond through a culvert under Pearl Street (Baystate 1980). Since the surface elevations of both ponds are 1103.5 feet (MSL), this is a single impoundment that "is split by the Route 101 causeway under existing conditions" (Gardner/DEM 1983; Shepardson 1981). At the outflow of Dunn Pond (see Station 7 on Fig. 2), Foster Brook courses southward for approximately 0.4 miles whereupon it is impounded as Murdock Pond. It then bends to the southwest through the south end of Gardner where it is further impounded as, sequentially, Travers, Bents, and Ramsdall Ponds. Foster Brook then dischargers to the Otter River about one mile south of Gardner. The Otter River is tributary to the Miller's River, which discharges its flow to the Connecticut River.

The natural beauty of Dunn Park/Pond and its close proximity to the City center made it the favorite spot for active and passive recreation, including nature walks and picnics. The Pond was described as "heavily utilized by fishermen" in a 1956 flyer (Appendix I) issued by the Massachusetts Division of Fish and Game (MDFG 1956). It was stocked annually by MDFG from 1945 to 1950, but it was evident from their 1951 survey that Dunn Pond had become "over-populated with panfish." As a consequence, it was partially drained by MDFG in September 1953 and the resident fish populations were killed with rotenone. The Pond was restocked in 1954 and 1955, and by 1956 the fish populations were "in a healthy state" (MDFG 1956). Pictorial results of a "fishing derby" sponsored by the Gardner Recreation Department in 1955 attest to the success of the restocking program (Appendix I). Ice fishing was also a popular activity, and Dunn Pond was "used quite heavily for skating," as described in a 1957 letter written by MDFG Chief Aquatic Biologist William A. Tompkins (Appendix I). Other common historical recreational activities included wading and non-motorized boating.

In less than 50 years, however, John Dunn's "beautiful sheet of water" became characterized as "one shaped primarily by urban storm water, dump leachate and sewer overflows and, to a lesser extent, by overland flow through wooded wetlands" (Gardner/DEM 1983). It was " shallow, muck floored, and weed infested" (Baystate 1980). In particular, "storm water runoff from about 105 acres" flowed into the Pond "from an existing network" of drain pipes, especially along the east and west bound lanes of Pearl Street. Human disturbance of vegetation at various points along the moderate to steep slopes around the Pond as well as storm discharges along Betty Spring Road (Fig. 2) also contributed to erosion and sedimentation (Baystate 1980). Although these problems were

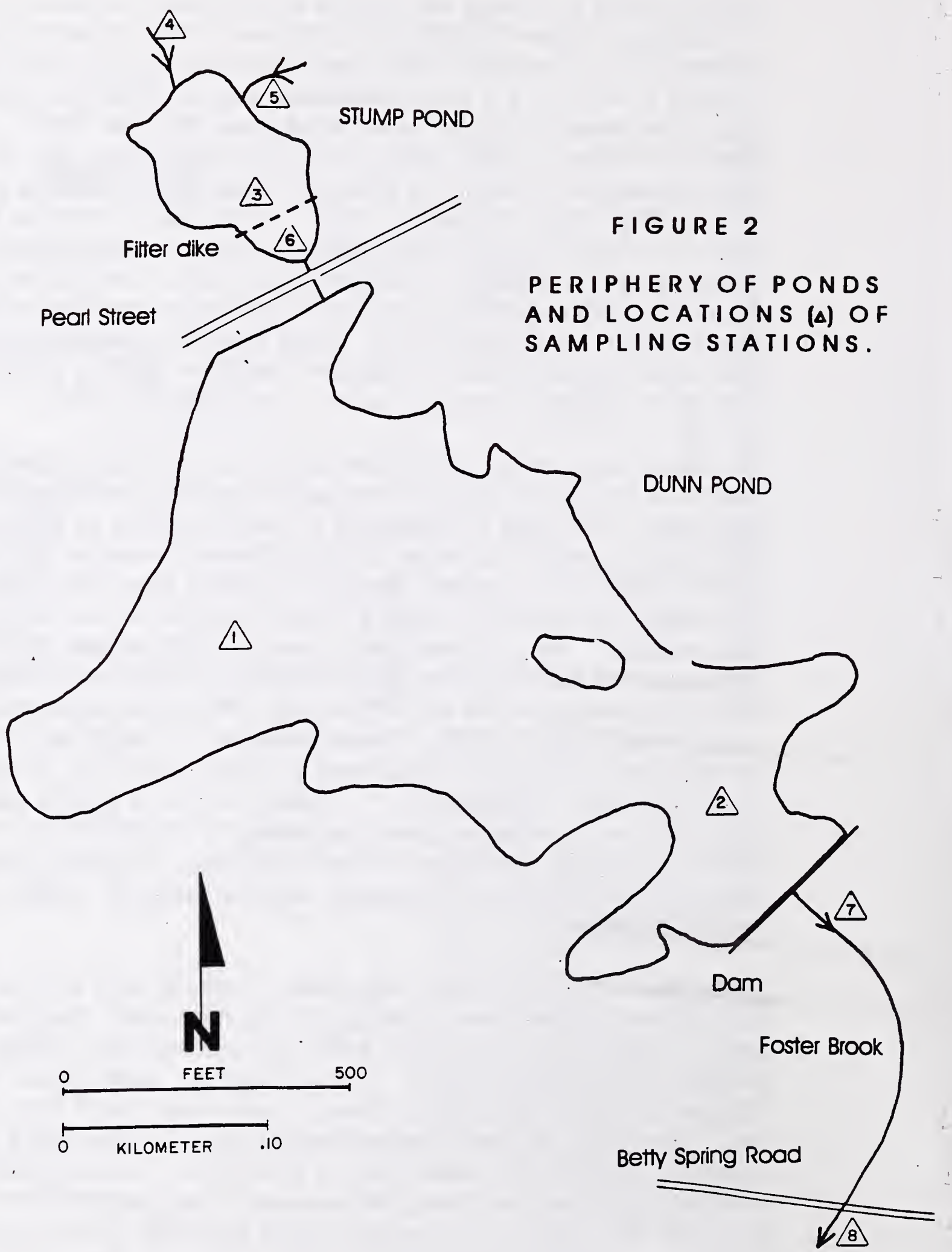


FIGURE 2

PERIPHERY OF PONDS AND LOCATIONS (△) OF SAMPLING STATIONS.

severe, they were localized and subject to management. It was indeed fortunate that Stump Pond served as a settling basin for "approximately 75%" of the Dunn Pond watershed (Gardner/DEM 1983).

Unfortunately, little historical information is available on Dunn Pond bathymetry. As a consequence, the rate of sedimentation, accumulation of partially decomposed plant tissue (peat), and corresponding loss of pond volume are difficult to assess quantitatively. A map attached to the January 9, 1945 MDFG Stocking Agreement with Gardner's Park Department specifies a depth of 9 feet. Presumably, this figure represents the maximum depth. The June 28, 1951 Pond Data Record compiled by the MDFG lists the Dunn Pond maximum depth at 5 feet and the average depth at 2.5 feet. However, the Record included a note under "Water Level" that the Pond's surface was down by 2-3 feet. Apparently, maximum depth would have been 7 to 8 feet if the Pond was at normal pool level (1103.5 feet). Maximum and average depths were 6 feet and 3 feet on June 18, 1980 according to the (renamed) Division of Fisheries and Wildlife (MDFW). These latter estimates closely approximate those recorded by the Division of Water Pollution Control in 1979. Little can be concluded from this scant information except that the maximum depth appears to have been reduced by approximately 30-35% since formation of the enlarged pond in 1934.

Hurricane Diane may have caused serious erosion and loading of sediments to Dunn Pond in August 1955, but there is no record of this in City reports or local newspaper articles (David Fournier, personal communication). Baldwin (1973) stated that Hurricane Diane damage "exceeded any previous hurricane of record in the United States" and that "heavy rainfall with near maximum runoff caused general severe floods of [the] entire northeast United States." The fact that the dam was "rebuilt after being destroyed by floods in 1955" (Shepardson 1981) more than hints of concomitant "severe erosion and loading of sediments to Dunn Pond."

The Massachusetts Division of Water Pollution Control conducted a routine, one-day baseline survey of Dunn Pond on September 13, 1979. At the time the Pond was "densely vegetated over most of its area." Nuphar variegata Durand (Yellow water-lily), Potamogeton sp. (Pondweed), Utricularia radiata Small (Bladderwort) and, in particular, Myriophyllum sp. (Milfoil) were the most common macrophytes. The MDFW surveyed Dunn Pond on June 18, 1980. MDFW reported that emergent vegetation covered approximately 60% of the Pond's surface area, that panfish were "extremely slow growing" and "overcrowded," and game fish populations lacked "quality size fish." Apparently, panfish sought refuge in the dense stands of vegetation, thus reducing predation by largemouth bass and chain pickerel. As stated elsewhere

in this report, the average depth of the Pond had been reduced to less than one meter (3 feet) at the time of these surveys. Thus, by the end of the 1970's, public recreation was severely impeded in this weedy, shallow, meadow-like eutrophic system.

The restoration of Dunn Pond can be traced to enactment of state legislation (Section 2 of Chapter 798 of the Acts of 1979) "Facilitating the Establishment of Urban Heritage State Parks." This legislation was initiated to foster tourism and improve the quality of life in economically stressed cities of the Commonwealth based upon the success of the Lowell Heritage State Park. In the summer of 1978, The Massachusetts Department of Environmental Management (DEM) and the Office of State Planning issued a Request for Proposals for Urban Heritage State Parks. Gardner Mayor Gerald E. St. Hilaire submitted a proposal in October in response to this RFP. On November 1, 1978, portions of the City, including the City-owned Dunn Park, were designated by DEM as an Urban Heritage State Park. Mayor St. Hilaire subsequently appointed a broad-based "Advisory Committee" to guide planning and development of Gardner's new Heritage State Park (GHSP).

In 1979, the Massachusetts State Senate and House of Representatives "made available through the capital outlay process the sum of $20 million to the DEM for the purpose of acquisition, development, and associated costs of establishing Urban Heritage State Parks in seven cities," including Gardner. The City's plan was to restore selected historical center-city sights and to link them with Dunn Park and Dunn Pond through a 1.5 mile semi-urban corridor. Storch Associates of Boston, Massachusetts was contracted by DEM in October 1980 to develop the following in sequential order: a) several conceptual sketches for each of four proposed park sites, including Dunn Park and Dunn Pond; b) schematic designs for each site based upon two selected conceptual sketches; and c) preliminary and final design plans for each park site.

The basic concept for Dunn Park and Dunn Pond included dredging Stump Pond and rerouting storm drains to discharge into this pond, which would effectively serve as a detention/retention basin for suspended solids. Dunn Pond would also be excavated. The onshore margin of Dunn Pond would be developed into walking trails with natural fitness stations, interpretive exhibits, play fields, a park center building, and a launch facility for non-motorized boats. A "conceptual sketch" of this plan is shown in Gardner/DEM (1983, Fig. 2).

It was also fortunate for the City of Gardner that regulations governing the U.S. EPA's Clean Lakes Program became effective on February 5, 1980. Seven months later, a meeting was convened at Gardner City Hall to explore the

feasibility of restoring Dunn Pond with a Section 314 Clean Lakes Program grant from the U.S. EPA (memorandum for the record by E. Chesebrough). The following individuals participated in this meeting:

Carter Terenzini - DEM Project Manager, Gardner Heritage State Park
Rick Pavoni - DEM Project Engineer, Gardner Heritage State
Michael Smith - Chairman, Gardner Conservation Commission
Arthur Young - City Engineer, Gardner
John Wagner - Storch Associates, Boston
Bill DeMarco - Harvard University
Eben Chesebrough - Mass. Division of Water Pollution Control

It was decided at the conclusion of this initial meeting that Eben Chesebrough would invite Ronald Manfredonia, the U.S. EPA's Clean Lakes Program Coordinator for Region I, to a second meeting and to participate in a site visit to Dunn Pond.

Ronald Manfredonia did meet with the aforementioned group of individuals at the Gardner City Hall on October 15, 1980 following a site visit to both Dunn Pond and Stump Pond (Memorandum for the Record by E. Chesebrough). Tom Hubbard, Gardner City Planner, was also in attendance, whereas Bill DeMarco was absent. The group in attendance discussed excavating Dunn Pond, "rehabilitating" Stump Pond to function as a settling basin, and rerouting storm drain discharges to Stump Pond. Of particular importance was the group's discussion of foregoing a Phase I Diagnostic/Feasibility Study and encouraging the State to apply for Section 314 funds to restore Dunn Pond as a Phase II project. It was decided that all available pond and watershed data would be assembled, and that the probability of initiating a Phase II project based upon the obvious condition of the Ponds would be discussed at the October 30-31 state/federal U. S. EPA conference in Philadelphia.

On November 17, 1980 Terenzini, Pavoni, Wagner, Hubbard, Chesebrough, and James Arnold (Division) convened a third meeting to discuss Arnold's presentation at the EPA conference in Philadelphia (Memorandum for the Record by E. Chesebrough). Arnold reported that the U.S. EPA's response had been favorable, and that the state could proceed with a Phase II application for the restoration of Dunn Pond. The U.S. EPA did, however, specify the following pre-conditions:

a) the chemical composition and depth of soft sediments in both Dunn Pond and Stump Pond needed to be determined;

b) design specifications for the diversion of storm water to Stump Pond needed to be developed; and
c) cost estimates of storm drain diversion needed to be specified.

It was also necessary to complete the application by December 15, 1980.

A Storch Associates subcontractor (Baystate Environmental Consultants, Inc. of East Longmeadow, Massachusetts) completed the Section 314 application three weeks later, and on December 12, 1980 John Wagner distributed three copies of the application to James Arnold. The application document (Baystate 1980) included EPA Form 5700-33, a forty-seven page Diagnostic/Feasibility Study, twelve photographs, and restoration plans. On February 4, 1981 U.S. EPA Region I Administrator William R. Adams, Jr. approved a grant offer to the Division of Water Pollution Control based on the application. Thus began the restoration of Dunn Pond.

FUNDING

The federal share of funding for the Dunn Pond Phase II project was provided through Section 314 of the Clean Water Act of 1977 (Public Law 95-217). Section 314 "directs the [U.S. EPA] Administrator to make financial assistance available to the States, and authorizes funding" (U.S. EPA 1980). Financial assistance was provided in the form of a cooperative agreement between the U.S. EPA and the Commonwealth's Department of Environmental Quality Engineering (name subsequently changed to Department of Environmental Protection), Division of Water Pollution Control (Division).

On February 4, 1981 the U.S. EPA offered the Division a financial assistance agreement (No. S001341010) in the amount of $625,000 for its share of the Dunn Pond Phase II Restoration Project. In turn, financial assistance for engineering services and construction was provided in the form of a Substate Agreement between the Commonwealth's Department of Environmental Quality Engineering and the City of Gardner. The actual expenditure of funds to complete this project was $1,263,891.26, and the federal share of that amount was $619,610.26.

The non-federal share ($644,281.00) of the total project cost was derived as follows: a) the Commonwealth's Chapter 628 (Acts of 1981) Clean Lakes and Great Ponds Program was the source of the state share ($337,170.74), as authorized by the Water Pollution Control and Water Conservation Loan Act of 1982 (Chapter 286); and b) the City of Gardner provided the "local" match ($307,110.26), which was actually derived from Heritage State Park funds

pursuant to provisions of Chapter 798 of the Acts of 1979, as amended by Chapter 512 of the Acts of 1980. According to DEM's Christopher Greene (personal communication), Heritage State Park funds were transferred to the City of Gardner under terms of a Memorandum of Understanding and Agreement (No. 512-17) dated May 28, 1982, per amendments No. 2 (dated November 30, 1982) and No. 3 (dated April 28, 1983). Amendment No. 2 added the restoration of Dunn Pond to the Scope of Services and provided the "local" match. Additional funds were added to the "local" match as needed in Amendment No. 3. The slight difference in relative contributions between federal (49%) and non-federal (51%) shares is attributable to additional cost absorbed by DEP for the analysis of water quality samples during the four-year, post-construction monitoring program of Dunn Pond.

It is appropriate to note here that certain parcels of parkland, including Dunn Park and Dunn Pond, are in the process of being transferred from the City of Gardner to the Commonwealth's Department of Environmental Management pursuant to Chapter 656 of the Acts of 1983. DEM staff have been managing the Gardner Heritage State Park and Dunn Park/Dunn Pond facilities even though titles to these properties are still being examined (personal communication with Bonnie Brown and Jennifer Howard of DEM).

ENVIRONMENTAL EVALUATION

As required, the Massachusetts Department of Environmental Management filed an Environmental Notification Form (ENF) with the Executive Office of Environmental Affairs (EOEA) on April 7, 1981. The ENF was filed for the entire Gardner Heritage State Park project, including improvements to the downtown area (Lafayette Square, West Gardner Square, and the Lake Street Fire Station), the 1.5 mile corridor to Dunn Park, and the restoration of Dunn Park and Dunn Pond. A copy of the ENF is provided in Appendix K of Storch (1981).

On May 7, 1981 EOEA Secretary John A. Bewick determined that an Environmental Impact Report would be required pursuant to M.G.L. Chapter 30, Section 62-A, and Section 10.04(9) of regulations governing implementation of the Massachusetts Environmental Policy Act (MEPA). Secretary Bewick's Scope for the EIR is also included in Appendix K of Storch (1981). The Scope pertained exclusively to the proposed Dunn Pond restoration project since more than 10 acres of wetland was subject to alteration. The potential environmental impacts that needed to be investigated are quoted below.

1. Determine the area and volume of dump material which must be removed from the bank of Stump Pond to eliminate the leachate problem. While

the analysis seems to indicate no hazardous material present, a disposal site and procedure acceptable to DEQE (renamed DEP) must be identified and presented.

2. Identify the source of and analyze the leachate emerging from under the spoil pile and access road which was utilized for constructing the Pearl Street Interceptor Sewer under Dunn Pond.

3. A major series of questions relates to the dredging of 125 thousand cubic yards of peat material from Dunn Pond. The EIR should identify feasible methods of accomplishing the dredging, to depths of ten and twenty feet from the present 2-3 foot average depth. The drain outlet at -8 feet, opened in September 1980 to lower the pond for the Sewer Interceptor construction, will facilitate some methodologies. A method of dewatering the dredge spoils to the point acceptable for transportation and delivery to the disposal or storage site must be identified. An acceptable disposal or storage site must be identified. Once the sites and methodologies are identified, a time schedule should be determined and siltation control strategies identified which will accommodate storms to be expected during a period of twice that length.

4. Although hydraulic calculations have been prepared for the redesign of Stump Pond as a siltation basin, they need to be refined to reflect the greater percentage of runoff which is expected to occur during 50 to 100 year storms (as opposed to 15 year storms.) A detailed description of the outfall structures for Stump Pond should accompany the hydraulic calculations.

5. The article 97 status of the Pearl Street Interceptor on the park land should be described. Massachusetts Division of Fisheries and Wildlife (West Boylston Office) has asked that some stumps for bass cover be retained in Dunn Pond to facilitate fisheries management.

In a partial response to EOEA Secretary Bewick's "Scope," Storch Associates produced a report in December 1981 (Storch 1981) that specified a dredging plan and a stormwater diversion plan. Subsequently, the Draft Environmental Impact Report (Gardner/DEM 1982) was submitted to EOEA on October 29, 1982; it was prepared by Gardner's Department of Community Development and Planning and the Commonwealth's Department of Environmental Management, with assistance from Baystate Environmental Consultants, Inc. and Storch Associates. The preparers of the Draft EIR addressed the environmental impacts of their proposed restoration project for Dunn Pond as well as measures to

mitigate these impacts, as specified in EOEA Secretary Bewick's "Scope for the EIR." On December 15, 1982 Secretary Bewick determined that the Draft EIR "adequately and properly" complied with applicable Massachusetts laws and regulations, but that "significant portions of the scope" were "not well addressed" (Section D, Gardner/DEM 1983). The four deficient areas are abbreviated below:

a) "not accurately determining the area and volume of dump material to be removed from the bank of Stump Pond;"
b) "not providing a workable erosion/sedimentation control plan for the Dunn Pond dredging and dewatering operations;"
c) "not discussing...recommendation...that a Phase II Archeological Report be prepared on the [late 19th and early 20th century] Stump Pond Dump Site;" and
d) lack of discussion concerning the applicability of Article 97 (Massachusetts Constitution), which prohibits disposal of public park land without approval of the Legislature.

The Final Environmental Impact Report (Gardner/DEM 1983) was submitted to the MEPA Unit of EOEA on February 15, 1983, and it was approved by Secretary James S. Hoyte on April 1, 1983 (refer to "Certificate of the Secretary" in Appendix II).

SCOPE OF SECTION 314 RESTORATION PROJECT

The discrete reimbursable tasks listed below are major components of the scope of work for the Dunn Pond restoration project, as specified under Section A.3 of the aforementioned Substate Agreement (refer to "FUNDING").

- Final design specifications and engineering documents.
- Acquisition of the Korhonen and Nygard properties for the disposal of excavated sediments.
- Excavation and disposal of Dunn Pond and Stump Pond sediments.
- Construction of a filter dike in Stump Pond to retain suspended solids and to reduce the concentration of total phosphorous in water passing through the dike.
- Diversion of storm water drainage to Stump Pond.
- Reconstruction of the culvert from Stump Pond to Dunn Pond.
- Removal of spoils from previous construction of the Pearl Street interceptor sewer along the north shoreline of Dunn Pond.
- Documentation of activities and results.

In addition, the City of Gardner was required to file and obtain all local, state, and federal permits as a non-reimbursable project task under Section A.4 of the Substate Agreement.

PERMITS AND CERTIFICATES

Copies of decisions rendered by local, state, and federal agencies with authority to issue permits or certificates pertaining to construction activities at Dunn Pond are included in Appendix II. Collectively, these actions served to complete task A.4.2. of the Substate Agreement.

PROJECT DESIGN AND CONSTRUCTION

Excavation of Sediments

The restoration of Dunn Pond was undertaken in a sequential series of construction tasks performed by Pacella Brothers, Incorporated of Plainville, Massachusetts. Initially, the contractor erected a check dam with silt curtain on the lake side of the Dunn Pond dam to prevent outflow of suspended solids to downstream water resources. Also, a stream bed was excavated to channelize inflowing water to a pool in front of the silt curtain. Water flowed by the force of gravity through the check dam/silt curtain barrier to the outlet of Dunn Pond.

Actual excavation of sediments began on January 7, 1984 (personal communication with Charles Swanson of Storch Associates). In anticipation of this dredging project, the Gardner Heritage State Park Advisory Committee persevered in keeping Dunn Pond drained for a period of two years following construction of the Pearl Street interceptor sewer. With conventional excavating and loading equipment, the contractor initially removed shore sediments, beginning near the access haul road at the north end of the Pond. Then, working inexorably toward the west bay, deep peat deposits were removed to a depth of about 24 feet with a long-reach backhoe. Except for this deep zone in the west bay and a zone at the south end of the Pond, peat and other sediments were excavated down to post-glacial deposits. Partial excavation of sediments at the south end of the Pond increased water depth in this zone, but unexcavated sediments were left in place to support a littoral community suitable for spawning and feeding by fish populations inhabiting Dunn Pond subsequent to restoration. This action served to mitigate the concerns of both the Massachusetts Division of Fisheries and Wildlife and the U. S. Fish and Wildlife Service as stated in letters of correspondence from Chris Thurlow and Gordon E. Beckett, respectively (copies of their letters are included in Appendix III).

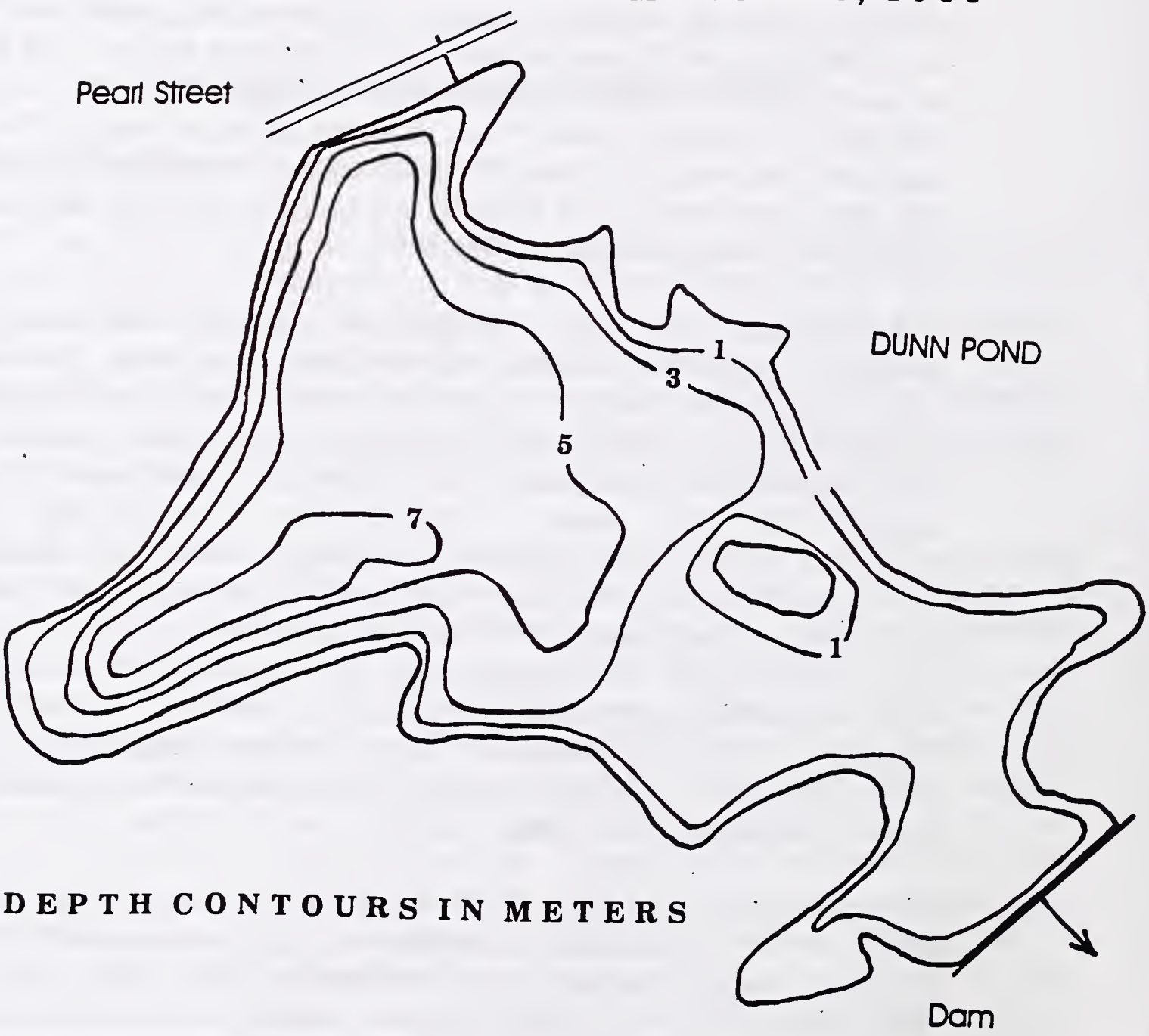
The post-excavation bathymetric contours of Dunn Pond are shown in Fig. 3, and the detailed final grading plan is provided in Appendix IV. A total of 220,362 cubic yards of sediment and peat were excavated at a total cost of $530,304.75, or $2.40 per cubic yard. The metric equivalent is 168,479 cubic meters at a cost of $3.15 per cubic meter. Included in the total cost are mobilization and demobilization of excavation equipment and disposal of dredge spoils; excluded are excavation costs for Stump Pond. Peterson (1981, as cited in Cooke et al. 1986) provided a range of costs from $0.24 to $14.00 per cubic meter for 64 lake sediment removal projects in the United States. The wide variability of costs reflect differences in methods of dredging, complexity of the projects, and the total volume of sediment excavated. However, the general rule of Cooke et al. (1986) that the "per-unit-volume cost of sediment removal will be inversely related to the total volume of material removed" likely explains the comparatively low cost of excavating Dunn Pond. It is interesting to note that the volume of sediments removed from Dunn Pond exceeded the previous Pond water volume (66, 608 cubic meters) by a factor of 2.5 based on the Pond surface area of 18 acres and its average depth of 3 feet.

The contractor began work at Stump Pond in January 1985, one year after the first haul of sediments had been excavated from Dunn Pond. An initial problem was the late 19th century - early 20th century dump located on the eastern shoreline (Fig. 4; modified from Huntington et al. 1981). Leachate from this dump degraded the water quality of both Stump Pond and Dunn Pond. All of the dump's 6293 cubic meters of material were excavated with conventional equipment at a cost of $3.28 per cubic meter, including disposal, following an archeological survey by Harvard University's Institute for Conservation Archeology (Huntington et al. 1981). Dump spoils were disposed of at the West Street landfill under an agreement with the Gardner Board of Health. Stump Pond was subsequently cleared and grubbed to remove all stumps, et cetera. Thereafter, 11,439 cubic meters of organic sediments and earth were excavated as the Pond was "contoured to enhance its sedimentation capabilities" and to provide additional flood storage capacity.

All excavation work for this Phase II project was completed by "noontime" on March 4, 1985. Most pond sediment and peat spoils were trucked to the 28 acre Korhonen property disposal site (DEM/Gardner 1982; 1983), which abuts the north side of Dunn Park. Disposal was confined to areas "A" and "B." The upper most stratum of stumps, roots, rocks and debris cleared and grubbed from both ponds was trucked to the City's West Street landfill. Also, prior to the restoration of Dunn Pond, "an area of about 3/4 acre" was cleared on the east side of the Pond to store spoils from construction of the Pearl Street interceptor sewer (Gardner/DEM 1983). The stumps, vegetative matter, loam, gravel and boulders in this spoils pile were re-excavated by Pacella Brothers, Inc. and

FIGURE 3

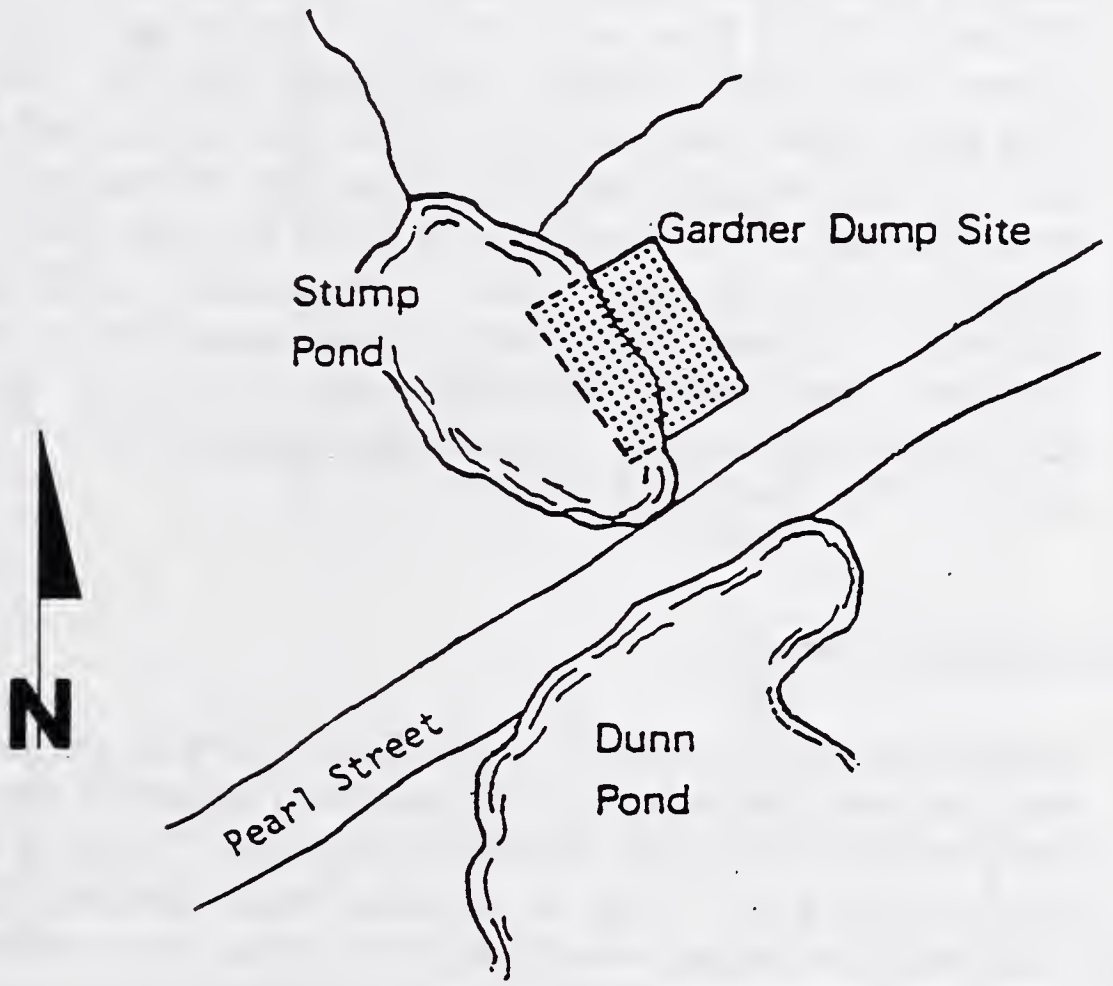
POST-CONSTRUCTION BATHYMETRY OF DUNN POND. MARCH 14, 1985



DEPTH CONTOURS IN METERS

FIGURE 4

LOCATION OF GARDNER DUMP ON THE EAST SHORE OF STUMP POND.



trucked to the West Street landfill.

Replacement of Interbasin Culvert

In the next phase of construction, the 42 inch culvert that linked Stump Pond to Dunn Pond was replaced with two 48 inch culverts (Fig. 5; modified from Gardner/DEM 1983). The design for the two culverts was "based on the 100 year storm," a necessary step to prevent water from overtopping Pearl Street. The existing 42 inch culvert was removed.

Diversion of Stormwater

Two significant changes were included in design plans to divert stormwater drainage from Dunn Pond to Stump Pond (Gardner/DEM 1982). "To the west of Dunn's [Dunn] Pond a new 36 [inch] pipe picked up the drainage from the systems with outfalls at Betty Spring Road (Fig. 2). This pipe ran along the south side of Pearl Street to the area of the parking lot, then across Pearl Street... and eventually emptying into Stump Pond. On the eastern side of Dunn's [Dunn] Pond, drainage from an existing 24 [inch] line was diverted into Stump Pond through a new 30 [inch] pipe. The existing outfall at Dunn Pond was abandoned." A new 12 inch drain was also constructed to pick up drainage from "additional catch basins" installed at the "low point" on Pearl Street. The stormwater diversion plan is shown diagrammatically as foldout Fig. No. 12 on page 41 of Gardner/DEM (1982).

Construction of Filter Dike

Construction of the filter dike was the last step to prepare Stump Pond as a detention/retention basin for stormwater and watershed runoff. As explained in Gardner/DEM (1983), the filter dike consisted of "layers of sand, gravel, crushed stone and rock fill" (Fig. 6; modified from Gardner/DEM 1983). It was "designed to withstand overtopping in extreme storm events without damage," and it can support the weight of small excavation equipment should the filter need to be repaired or replaced.

The dike was further designed to retain and filter all water discharged to Stump Pond during a 1 inch rainfall, which includes approximately 90% of the total annual stormwater flow in this area (Gardner/DEM 1982). During a 1 inch rainstorm, the Stump Pond water level should rise from 1103.5 feet to approximately 1106 feet as water is stored (Fig. 7; modified from Gardner/DEM 1983). Stump Pond "will gradually dewater" following rainstorms, as water

FIGURE 5

TYPICAL SECTION OF DIKE,
CULVERTS, AND PEARL STREET EMBANKMENT.

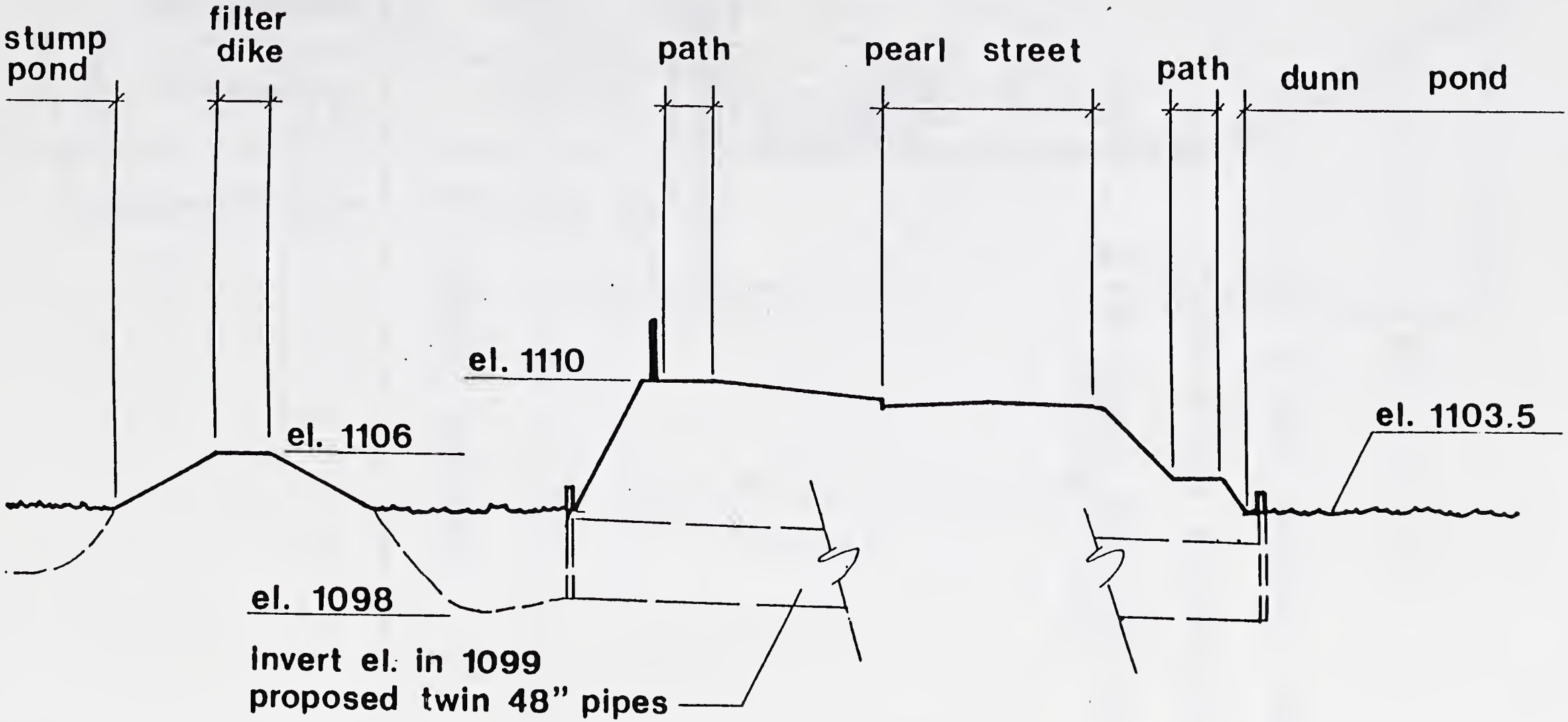


FIGURE 6

TYPICAL SECTION OF FILTER DIKE.

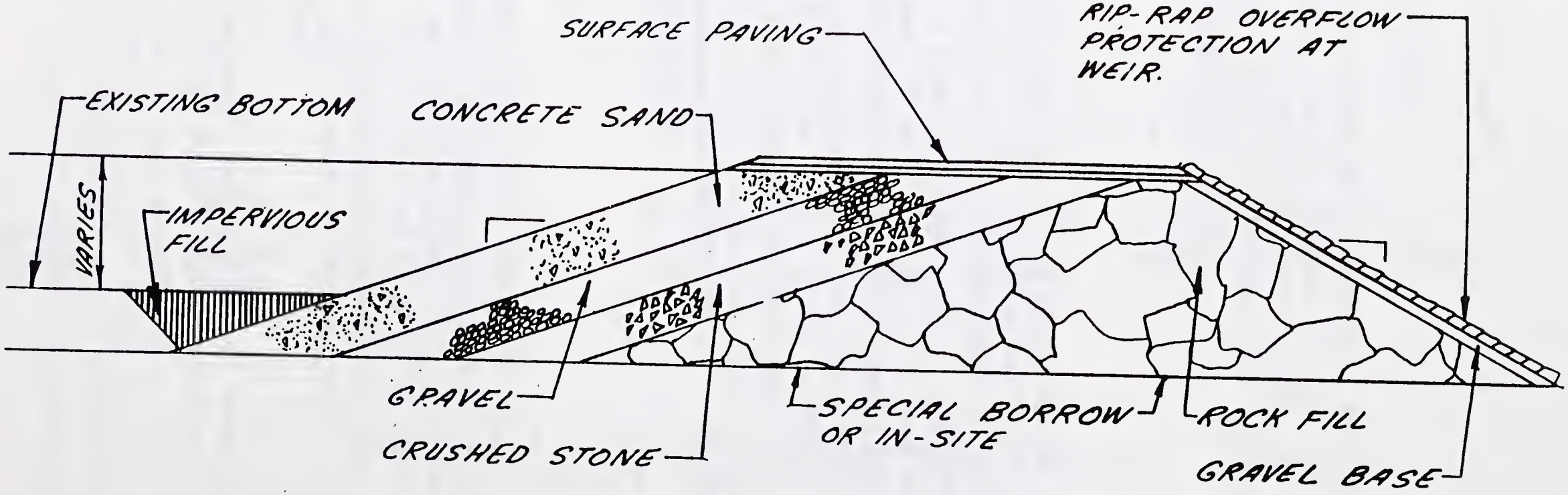
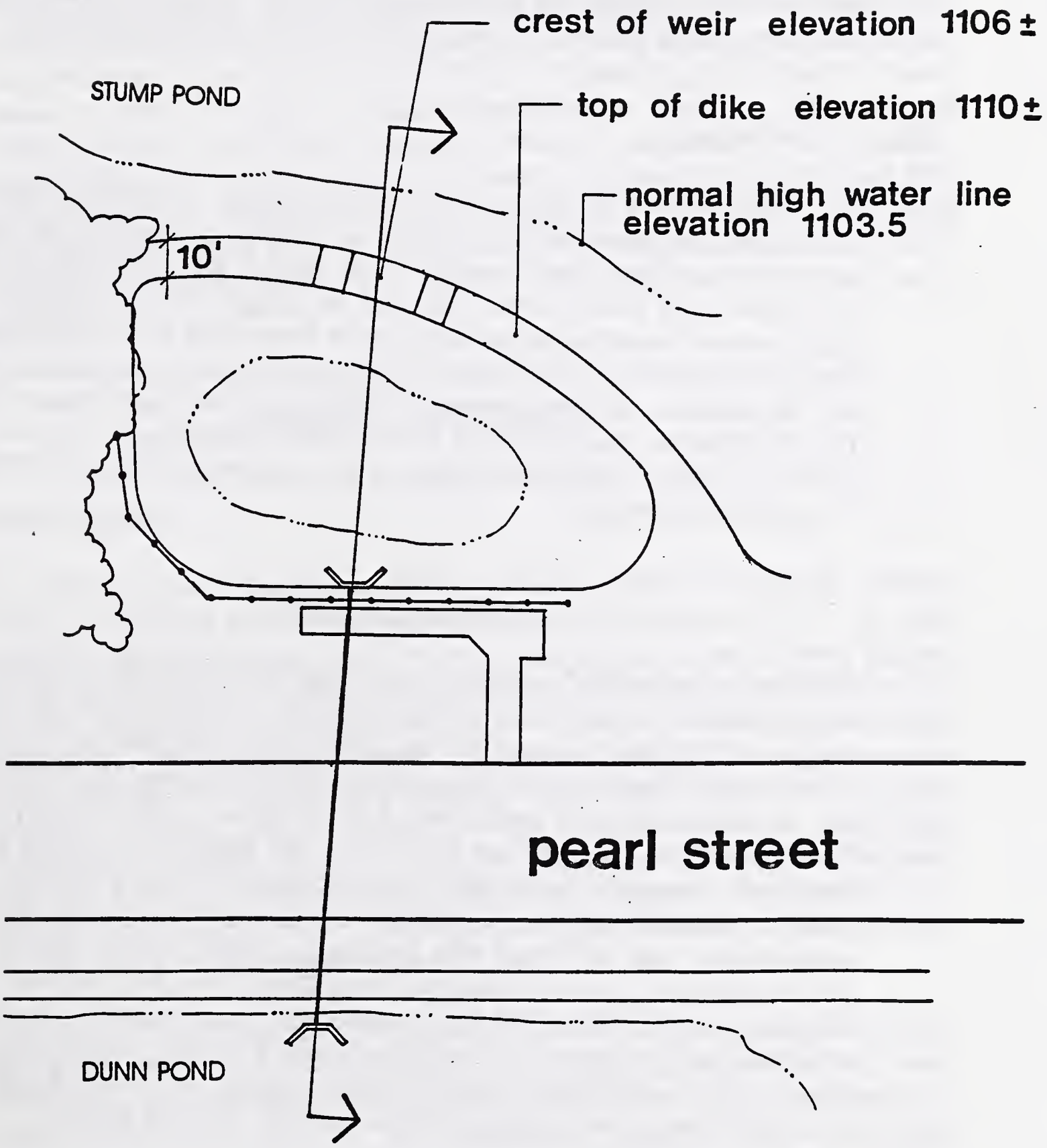


FIGURE 7

PLAN OF FILTER DIKE AND CULVERTS.



filters through the dike, until its surface returns to 1103.5 feet.

During the dewatering process, layers of fill in the dike trap suspended particles, thereby preventing the loading of suspended solids to Dunn Pond. Equally important, filtration also removes phosphorus. It was estimated (Gardner/DEM 1982) that the "combination of sedimentation and filtration" would effectively remove "about 90% of the total suspended solids" that entered Dunn Pond prior to the restoration project and "about 70% to 90% of the phosphorus."

Filling of the Ponds

The filling of Dunn Pond actually began in February, 1985, when the contractor ceased pumping pooled water to the outlet. Officially, however, the lower level control gate of the dam was closed on March 6th upon completion of all excavation work and the Pond's normal pool level was re-established in early April (personal communication with Charles Swanson of Storch Associates). The final site inspection for this Phase II restoration project by personnel representing the Department of Environmental Quality Engineering/Division of Water Pollution Control, Department of Environmental Management, City of Gardner, Storch Associates, and Pacella Brothers, Inc. occurred on May 17, 1985. Thus, Dunn Pond was restored.

PROJECT DELAYS

With the exception of "landscaping and planting," all general construction work (e.g., dredging, storm drainage improvements, construction of the dike, entry roads, and parking lot) was to "be substantially complete on or before 180 calendar days" from commencement of the contract executed by Pacella Brothers, Inc. on August 24, 1983 (quote from p. 2 of contract). For a variety of reasons Pacella Brothers, Inc. were not able to meet this deadline, or several subsequent deadlines. Among these reasons were 54 working days lost to inclement weather (refer to Appendix V), 25 calendar days lost to a work stop order (discussed in detail below), and additional time lost during project change orders. Also, a larger volume of peat was excavated from Dunn Pond than originally planned. Extensions of 30, 60 and 120 days, sequentially, were granted to the contractor, who eventually "completed excavation of Dunn Pond and all shaping on 3-4-85" (Zenger 1985). This date is approximately one year beyond the original contract limit of 180 days, or the end of February, 1984, as noted above.

One persistent construction problem was the pooling of water near the deepest

point of sediment removal. Although this was due in some measure to direct precipitation and runoff, it was primarily a consequence of subsurface and ground water seepage, particularly in the west cove area. Apparently, Betty Spring Road was aptly named. To circumvent this persistent problem, Pacella Brothers, Inc. pumped pooled water to the channelized streambed that carried inflowing Foster Brook water to the silt curtain barrier that they erected near Dunn Pond dam. This barrier eventually proved unequal to the task, especially when the contractor began excavating pockets of clay sediments, and excess loads of suspended solids were released to the outlet of Dunn Pond. Project Engineer Ricardo Pavoni issued an order to suspend dredging operations on April 7, 1984 (personal communication with Charles Swanson of Storch Associates). The stop order remained in effect until the contractor erected a temporary stone dam and took other measures to mitigate this particular problem. This subject is discussed more thoroughly under the forthcoming section on "PROJECT EVALUATION." Sediment removal was resumed on April 27th, 1984, and no further delays were reported.

PROJECT EVALUATION

Monitoring Program

The Massachusetts Division of Water Pollution Control, Technical Services Branch, monitored the restoration of Dunn Pond and Stump Pond. The main objectives of this program were to reveal and document any adverse impacts during construction, demonstrate expected water quality improvements following implementation, and establish a database on the "newly formed" and much deeper Dunn Pond. Pre-project monitoring extended from June 1982 through December 1983, although the contractor was building access haul roads and preparing the Korhonen disposal site at the end of this interval. On-site construction commenced on January 7th, 1984, when the first haul of sediments was removed from Dunn Pond. This monitoring phase was continued until the Pond was refilled in early March, 1985. Post-implementation monitoring began on March 13, 1985 and it extended until August 1, 1989.

There was no consistent pattern of monitoring over the seven year period except for the first two years following construction. During that interval surveys were completed at least monthly, with a few exceptions in the winter, and usually on a biweekly basis throughout the "growing season." Inflow, in-lake, and outflow water quality were monitored at eight stations as diagrammed in Fig. 2 and as described on the following two pages.

Station 1. An in-pond station located at the deepest point of the newly excavated Dunn Pond. Vertical profiles of temperature, dissolved oxygen, pH, and specific conductance were measured *in situ* at meter intervals to 7 meters. Other chemical parameters were typically measured from samples collected just below the Pond's surface and at the 7 meter depth.

Station 2. An in-pond station located in a shallow, least disturbed area (limited sediment removal) south of the island.

Station 3. Stump Pond side of the filtration dike. Grab samples were collected at the water's edge near the center of the dike.

Station 4. Tributary (Foster Brook) discharging to the northwest shoreline of Stump Pond. Access to this site was along the east shore of Stump Pond, then along an unmarked trail through the woodland that more-or-less paralleled the north end of the pond. Samples were collected upstream of the point where the trail crosses the brook.

Station 5. Tributary discharging to the north end of Stump Pond. Access and sampling are as described for Station 4 above.

Station 6. Interbasin flow from Stump Pond to Dunn Pond. This station was sampled on the north side of Pearl Street at the headwall of the 42 inch interbasin culvert prior to and during the construction phase of the project. An exception occurred on October 29, 1984 when samples were collected below the cofferdam at the south end of Stump Pond. Beginning on March 13, 1985, all subsequent (post-construction) sampling was from the new headwall that supported twin 48 inch culverts. It is assumed that Station 6 represent dike-filtered water after March 13, 1985, although this interbasin pool is hydraulically contiguous with Dunn Pond.

Station 7. Outlet of Dunn Pond. This station is located below the spillway and energy-dissipating riprap structures. Access to this station was from Betty Spring Road along the interceptor sewer right-of-way or by boat.

Station 8. Foster Brook just south of the Dunn Pond outlet. Samples were collected at the upstream end of the culvert that passes under Betty Spring Road.

Station 9. Foster Brook between Betty Spring Road (Station 8) and Murdock Pond, but northwest of its confluence with an unnamed tributary. Access to this station was from Betty Spring Road. Note: this station was sampled only during April to December 1984 as part of a supplemental monitoring program that is described elsewhere in the text.

Station 10. Unnamed tributary to Murdock Pond north of its confluence with Foster Brook. This station was sampled on the north side of Betty Spring Road. The "note" described for Station 9 applies to this station as well.

Station 11. Outlet of Murdock Pond. Access to this station was by way of a gravel road that formed a "T" junction with Betty Spring Road just east of Station 10. The "note" described for Station 9 applies to this station as well.

At each station, and on each sampling date, data were typically generated for the following chemical and physical parameters: total solids, suspended solids, total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen, total hardness, total alkalinity, chloride, specific conductance, pH, dissolved oxygen, and temperature. The last four parameters were measured with a Hydrolab® Digital 4041 field unit. On some dates samples were also collected to estimate fecal and/or total coliform bacteria. Secchi disk transparency was measured at Station 1.

Measurements of turbidity were made at least monthly on samples collected at Stations 6 through 11 during the supplementary monitoring program. This action followed a construction stop order that was discussed previously under "Project Delays." Similar measurements were made at Stations 04 and 05 from October through December of that year, 1984, presumably as additional "background" sites. Turbidity measurements were made on location with a Hach Model 2100A Turbidimeter that was calibrated with formazin reference standards. Results are reported in Jackson Turbidity Units (expressed as JTU in this report).

A 2 liter volume PVC Kemmerer bottle with neoprene end caps was used to collect in-lake water samples at various depths; otherwise, grab samples for chemical parameters were collected by hand in 1 liter glass bottles with Teflon-lined caps. A separate bottle was used to collect water samples for analyses of total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, nitrate nitrogen, and total hardness at each station. These samples were fixed upon collection with 4 milliliters (ml) of 1:1 sulfuric acid. Grab samples for coliform bacteria were collected in 200 ml autoclaved bottles. All water samples were labeled, placed

in insulated chests with ice, and transported to the Department's Lawrence Experiment Station for analytical tests following the most recent edition of either Standard Methods for the Examination of Water and Wastewater, which is published jointly by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation, or the U. S. Environmental Protection Agency's Methods for Chemical Analysis of Water and Waste.

In addition to chemical and physical parameters, the monitoring program included assessments of shallow water aquatic plants, or macrophytes, the open-water phytoplankton community (Stations 01 and 02), and the chlorophyll content of phytoplankton. Annual macrophyte surveys were completed during the post-construction years of 1985 to 1988, inclusively, and a follow-up survey was conducted in 1991. Macrophytes were identified to species, when possible, and the frequency of occurrence of each species population was estimated. The percent cover by all macrophytes was estimated as well, and these data are presented graphically in the report.

Phytoplankton were collected by several sampling procedures. Grab samples were filled just below the Pond's surface with a 1 liter glass bottle. Integrated water column samples were collected at Station 1 with a 1 centimeter (ID) flexible Tygon® tube, usually to a depth of 3 meters. Sometimes several integrated samples were composited into the same vessel. All phytoplankton samples were tagged and stored in a cooler with ice; these samples were typically refrigerated overnight. Subsequently, genera were identified from sub-samples prior to enumeration. One milliliter sub-samples were examined at 200X magnification in a Sedgwick - Rafter chamber; plankters viewed within multiple strips or fields were counted depending upon the relative density of the community. Density is reported in "units" (cell, clump, cluster, filament, etc.) per milliliter.

Chlorophyll was derived from samples of phytoplankton collected at Station 1, as described above. Upon return to the laboratory, a 50 milliliter sub-sample was filtered through a 2.1 centimeter Reeve angel, grade 934H, glass fiber filter that was supported on a Millipore side-arm vacuum flask assembly. A vacuum of 15 inches Hg was applied with a General Electric pump rated at 1/3 horsepower. Filters were removed with micro-forceps and placed in 2 inch Whatman Petri dishes, which were labeled and wrapped completely in aluminum foil. The foil-wrapped Petri dishes were stored in a freezer until recovered for subsequent analyses. A Thomas tissue grinder was used to macerate previously frozen filters upon addition of 3 milliliters of 90% acetone and 0.2 milliliters of a saturated $MgCO_3$ solution.

The contents of the tissue grinder, including several rinses, were transferred to a 15 milliliter graduated centrifuge tube and the sample volume was increased to 10.0 milliliters with 90% acetone. Once wrapped in aluminum foil, centrifuge tubes were refrigerated for 24 hours to facilitate additional dissolution of chlorophyll in the solvent. Insoluble cell fragments and filter remnants were pelletized at the bottom of the conical vessel following 20 minutes of centrifugation in a Fisher Scientific Safety Centrifuge. The supernatant in each centrifuge tube was transferred to a clean borisilicate cuvette after the chlorophyll solution warmed to ambient room temperature. Analysis of chlorophyll content was done fluorometrically using either a Turner III or Turner Design fluorometer with 3 inch or 8 inch cuvettes, respectively. Both fluorometers were zeroed with a 90% acetone blank. Since chlorophyll **a** and chlorophyll **b** cannot be distinguished with this fluormetric method, results are reported as chlorophyll in mg/m^3.

The tabulated databases for the seven-year monitoring program are presented in Appendices VI, VII, and VIII. Since there are in excess of 6600 entries, analysis and interpretation was limited to those data that would be useful in answering questions related to the purposes of the monitoring program, which have been stated previously. Also, as stated previously, the emphasis of the "PROJECT EVALUATION" section will be an examination of the impact of construction activities on downstream water quality, water quality improvements subsequent to the restoration project, and a description of Dunn Pond in its restored state.

Pre-construction Phase

Pre-construction monitoring was initiated on June 17th, 1982 and it continued until January 5th, 1984. Water quality data for this extended interval are included in Appendix VI. Most evident among the entries in this database are those of pH. These data are clearly indicative of a poorly buffered and acidic natural drainage to Stump Pond and, subsequently, to Dunn Pond. This is not atypical in north central Massachusetts. As reported on page 7 in Baystate (1980), "The region is covered mainly by glacially deposited soils. The soils are predominantly stoney [stony] or very stoney sandy loams to loams. They are low in silt and clay, and strongly acidic." The acidity of the water is also a function of high concentrations of dissolved organic acids, derived from incomplete decomposition of aquatic and wetland plants in the natural drainage area, and low concentrations of calcium, as evidenced by low values of total alkalinity and hardness (Appendix VI). These same organic acids impart a dark, tea-color to Dunn Pond water as a consequence of their differential absorption of subsurface radiation. This cause-and-effect relationship only hints at the role these organic acids play in governing the annual temperature cycle of the Pond, a subject that will be discussed under "Dunn Pond Restored."

The ranges of pH at Stations 4 (4.2 to 4.3 units) and 5 (4.0 to 4.5 units) serve as testimony to the acidic waters typically flowing from the drainage area north of Stump Pond as described above. The corresponding ranges of total alkalinity are 1 to 2 mg/L and 1 to 3 mg/L, respectively (Appendix VI). As one moves "downstream" to Stations 6, 7, and 8 there is a noticeable decrease in acidity, that is, an increase in recorded pH, and an increase in total alkalinity. For example, the corresponding ranges of values at Station 8 were 4.7 to 5.4 units and 2 to 8 mg/L, respectively. Whether this simply reflects the fact that the sloped margins of Dunn Pond exhibit only a thin veneer of soil overlying "coarse-grained, deeply-folded metamorphic rocks typical of the Upland Plateau in central New England" is unknown (quote is from p. 7 of Baystate 1980). That is, Dunn Pond may receive a contribution of cations, such as calcium, from these areas by ionic weathering of bedrock that may, in turn, buffer the acidic drainage from Stump Pond. As indicated elsewhere in this report, there was considerable subsurface flow in the west cove area of Dunn Pond adjacent to Betty Spring Road. Another likely source of buffering agents is the large volume of stormwater runoff that was discharged to Dunn Pond from Pearl Street and Betty Spring Road. The dilution of natural drainage to Stump Pond by combined subsurface and stormwater flows might adequately account for the reduced hydrogen ion activity and increased alkalinity measured at downstream sites. This subject will be discussed further under the sub-heading "Dunn Pond Restored."

There are two dates during pre-construction monitoring when data recorded for several parameters appears to be out of the normal range. On July 13th, 1983, between Stations 6 and 8, dissolved oxygen declined by nearly one-half, hydrogen ion activity increased nearly ten-fold (approximate increase of 1 unit on pH scale), hardness increased more than three-fold, and total suspended solids increased from "not detected" to 38 mg/L (Appendix VI). A note on the field sheet for that date by DEP/DWPC personnel indicated that water quality measurements at Station 8 "may be affected by ongoing repairs" to the 10 foot overflow spillway at the west abutment of the dam. Station 7 was not sampled for this same reason. The disrepair of this part of the dam was documented in an inspection report prepared on October 26, 1982 by Joseph. A. Sinnott of the Dam Inspection Unit, Massachusetts Department of Environmental Management. Sinnott wrote the following comments with respect to the emergency spillway: "Poor condition. Concrete wall is cracked and buckling. Some spalling." Apparently, repairs to the emergency spillway were undertaken to satisfy Award Condition No. 4 of the federal grant; that is, the project had to meet "the requirements of EPA Clean Lakes PM80-1 relating to dam safety" (Storch 1981, pp. 22 - 24). This award condition was promulgated in an EPA memorandum to Water Division Directors and Clean Lakes Coordinators by Joseph Krivak, then Acting Director of that agency's Criteria and Standards Division. A copy

of this memorandum is provided in Appendix IX. The City of Gardner did execute a short term contract in June of 1983 with R. Bates & Sons, Inc. of Clinton, Massachusetts for this purpose. Repairs to the emergency spillway were completed on July 14th, the day following the survey measurements discussed above. In a follow-up inspection of the dam on August 29th, 1983, David C. Thoen noted that the emergency spillway was in "good" condition, as was the entire dam.

The second date is January 5th, 1984. Particularly noticeable on this date were substantive increases in specific conductance and chloride. In this instance measurements of chloride were elevated about three-fold above the prior sampling date of November 21, 1983 at Stations 6, 7, 8. The corresponding elevations of specific conductance at the latter two stations was from 78 and 79 μmhos/cm to 130 and 132 μmhos/cm, respectively. Less evident was the rise from 77 to 96 μmhos/cm at Station 6. At the time Dunn "Pond" was drained, sediment excavation was scheduled to begin in two days, and Foster Brook coursed its way from inlet to outlet. It is likely that these "blips" in the data represent an impact to Foster Brook from "deicing" Pearl Street with rock salt (sodium chloride). However, I could not confirm that Gardner's Department of Public Works actually applied rock salt to Pearl Street in the vicinity of Dunn Pond on or prior to January 5th since the DPW purges its files after seven years.

The remaining "pre-construction" data in Appendix VI are neither remarkable nor instructive. A possible exception is 24 mg/L of total suspended solids (hereinafter referred to as TSS) recorded for Foster Brook at Station 4 on June 16th, 1983. Even though 0.5 inches of precipitation was measured for the previous day, I suspect that the 24 mg TSS/L is attributable to the disturbance of stream sediments when the sample was collected. The comparatively low concentration of 3 mg TSS/L at nearby Station 5 lends credence to the aforementioned interpretation. Also, sample collection error is the most likely explanation for the 36 mg TSS/L recorded at Station 4 on July 2nd, 1985 (post-construction period). Otherwise, the remaining 21 measurements of TSS at this station covering a period of six years varied within a narrow range of "not detected" to 7 mg/L (Appendix VI).

Construction Phase

As mentioned previously, the contractor's sediment trap proved to be inadequate after three months of excavation and excess loads of suspended solids were released to the Pond's outlet. To my knowledge there is no record of the severity of that discharge, but TSS measured at the outlet (Station 7) increased from 1 mg/L on March 8th to 18 mg/L on March 28th. Presumably conditions got worse because Project Engineer Rick Pavoni had to issue a stop order to suspend dredging on April 2nd. Duncan Burns, Chair of the Gardner

Conservation Commission, required a meeting at the project site for the purpose of mitigating this problem. In attendance were Rick Pavoni, Peter Sabettini (Gardner Conservation Commission), Michael Ackerman (Project Manager, Division of Water Pollution Control), Carlos Carranza (Baystate Environmental Consultants, Inc.), Charles Swanson (Storch Associates), and Joseph Zenga (Pacella Brothers, Inc.). The "Proposed Mitigation Measures" to be discussed at this meeting are included in Appendix X.

After a tense "discussion," a tentative agreement was reached among the participants that the contractor needed to erect a "course rock berm filter" and silt curtain at the outlet to prevent further discharges of highly turbid water to Foster Brook. This structure would more closely approximate that designed for the project (Storch Associates 1983). A verbal agreement was reached between Pacella Brothers, Inc. and the City of Gardner at a meeting held on April 19th, and an April 24th letter signed by Mayor Charles P. McKean and Michael Pacella "formalized" this verbal agreement. A copy of this letter is included in Appendix X. The agreement required Pacella Brothers, Inc. to construct both a "forebay settling pond" and "course rock berm filter" near the outlet of Dunn Pond to prevent the discharge of excess suspended sediment to Foster Brook. The trigger limit would be 50 JTU as specified in the contract document (Storch 1983, p. S-2G.1). The agreement further specified that the "Resident Engineer," or Rick Pavoni, was to take "samples and readings of the discharge from Dunn Pond" on a daily basis and to notify the Conservation Commission "immediately" if the 50 JTU limit was exceeded. Apparently turbidity data from these samples is no longer available, but Rick Pavoni has informed me that none of the measurements exceeded 50 JTU.

In addition to the mitigative measures discussed above, a supplemental monitoring program was instituted by the Division at the suggestion of Michael Ackerman. This included more downstream sampling sites (Stations 9, 10, and 11 as described under the "Monitoring Program") and measurements of turbidity. The supplemental monitoring program was continued until excavation of Dunn Pond was completed in December 1984. Turbidity data are presented in Table 1.

These measurements are comparatively low for a discharge from a dredging project. The maximum of 21 JTU was recorded from a sample collected at the outlet of Dunn Pond (Station 7) on July 12, 1984. Other downstream sampling sites (Stations 8, 9, and 11) also exhibited maximum turbidity measurements on this date. The only other double-digit measurement was 10 JTU recorded for Station 7 on September 10, 1984. These data appear to be high when compared to "background" turbidity measurements of 0.6 and 1.0 JTU recorded for Station 6 on July 12 and September 10, respectively. They are generally high also when compared to data for Station 10 (Table 1), a nearby unnamed tributary to

Table 1. Turbidity recorded for Stations 6 through 11 during the supplemental monitoring program. Results are expressed in Jackson Turbidity Units. NF indicates no flow on sampling date.

Date of Sampling (1984)	Sampling Stations					
	6	7	8	9	10	11
April 30	0.3	8.0	2.0	0.4	1.0	1.0
May 10	0.3	3.8	2.5	0.1	2.6	3.8
June 26	0.7	6.2	5.5	6.2	0.2	2.8
July 12	0.6	21	19	11	0.2	9.4
Aug. 1	1.2	8.0	7.0	4.0	0.2	4.3
Aug. 13	1.5	6.8	6.7	5.3	0.6	4.0
Aug. 23	1.1	5.5	3.8	2.2	0.5	0.4
Sept. 10	1.0	10	3.8	1.4	NF	1.4
Sept. 24	NF	5.5	3.9	1.7	NF	1.6
Oct. 15	NF	2.0	1.8	0.1	0.5	0.4
Oct. 29	1.6	8.5	4.2	1.0	0.3	3.0
Nov. 28	<0.1	1.3	1.2	1.0	<0.1	<0.1
Dec. 13	0.5	1.0	1.0	0.5	1.2	1.3
Time-weighted means	0.7	6.8	4.9	2.8	0.8	2.7

Murdock Pond. However, turbidity data in Table 1 are well below the 50 JTU limit established to mitigate the impact of excavation on Foster Brook, which is consistent with data generated by Rick Pavoni. Further evaluation of these data are presented in forthcoming paragraphs.

There is a general trend evident in Table 1 of increased turbidity below the construction site (Station 7) followed by substantive declines downstream of the outlet on all but one date (June 26). This trend is further revealed in a

comparison of time-weighted means for Stations 6 through 9 at the bottom of Table 1, although the means for Stations 7, 8 and 9 are skewed somewhat by the comparatively high turbidity values recorded for July 12. Measurements of turbidity for the outlet of Murdock Pond (Station 11) do not fit the aforementioned pattern. This is an expected outcome since suspended solids would likely settle to the bottom as flow from Foster Brook subsided upon entering Murdock Pond. Also, there would be the confounding effect of production by the pond's plankton community prior to the discharge of water at the outlet. Dunn Pond's outflowing and downstream waters exhibited low turbidity toward the end of the excavation project as recorded values more closely approximated background conditions at Station 6 (refer to November and December values in Table 1).

An analysis of TSS data (Table 2) recorded for Stations 6 through 11 during the supplemental monitoring program reveals essentially the same patterns as described above for turbidity. The increase in solids at Station 7 compared to Station 6 is evident on all survey dates as is the subsequent decline at downstream stations. The only exception to the latter occurred again on June 26th at Station 9 (Table 2). There is no notation of observed turbidity by Division staff for this particular station, so the probable cause of the elevated suspended solids and turbidity is not known. It is interesting to note that nearby Station 10, the unnamed tributary to Murdock Pond above its confluence with Foster Brook, exhibited its lowest suspended solids content and second lowest turbidity measurement on this same date. Therefore, it seems that the problem described above was quite local to Station 9 and its periphery, or perhaps stream sediments were disturbed during the collection of samples. Other than this anomaly, the suspended solids load at Station 9 was quite similar to that recorded for Station 6, indicating that any downstream impact of the construction discharge was largely confined to stream reaches above this site.

Another correspondence to turbidity data occurred on July 12 when TSS measurements for Stations 7, 8 and 9 were 20, 16, and 5 mg/L, respectively, which are among the highest recorded for each station during the supplemental monitoring period. This was the maximum load of TSS recorded for Foster Brook following construction of the temporary stone check dam and other mitigative measures at the pond outlet. In part, the load of suspended solids may be attributable to antecedent rainfall since 3.2 inches of precipitation was recorded for Gardner during the preceding six days and an additional 0.1 inch of rain was recorded on the date of sampling (NOAA, July 1984 [v. 96, n. 7, p. 12]). The highest concentration of TSS (25 mg/L) during the supplemental monitoring program was recorded for Station 7 on August 23rd, but this datum is not consistent with other downstream concentrations recorded for this date (Table 2) or with the corresponding turbidity measurement of 5.5 units. A

Table 2. Total suspended solids recorded for Stations 6 through 11 during the supplemental monitoring program. Results are expressed in milligrams per liter (rounded to nearest whole number). NF = No flow on sampling date; ND = Not detected.

Date of Sampling (1984)	Sampling Stations					
	6	7	8	9	10	11
April 30	1	12	3	1	2	2
May 10	ND	4	4	2	1	3
June 26	2	6	5	15	1	2
July 12	4	20	16	6	2	8
Aug. 1	4	9	6	2	6	3
Aug. 13	4	11	5	3	2	3
Aug. 23	4	25	5	4	3	5
Sept. 10	1	7	2	ND	NF	1
Sept. 24	NF	19	7	5	NF	6
Oct. 15	NF	7	3	2	4	3
Oct. 29	6	16	8	2	3	7
Nov. 28	4	7	6	3	1	3
Dec. 13	4	9	9	5	4	4
Time-weighted means	3	10	6	4	2	4

similar discrepancy between TSS and turbidity data is noted on the 24th of September for this same station. In the process of evaluating and interpreting these data I was guided by the presumption that optically measured turbidity, calibrated to a standard reference suspension, is a more accurate index of the total clay, silt, and organic suspension discharged from Dunn Pond then are gravimetric measurements of solids, which are prone to considerable error. As reported in Standard Methods (American Public Health Association 1985), "The standard deviation [for total suspended solids] was 5.2 mg/L (coefficient of variation 33%) at 15 mg/L in studies by two analysts of four sets of 10 determinations each."

Was there an adverse impact of excavating Dunn Pond sediments on downstream fish and wildlife subsequent to the construction stop order issued in early April

1984? To answer this question I examined the standards of bordering states for Class B waters supporting warm water fish since Massachusetts has not included numerical criteria for either turbidity or total suspended solids in its water quality standards . New Hampshire and Vermont 1988 standards (U. S. EPA 1988) both specify that turbidity shall not exceed 25 units in these habitats, but Jackson units are not specified. Connecticut's standards include the unequivocal statement that "Turbidity shall not exceed 25 JTU in Class B warm-water habitats." Also, an Advisory Committee Report (Anon. 1968) to the Federal Water Pollution Control Administration included the recommendation that "Turbidity in receiving water due to a discharge should not exceed 50 JTU in warm-water streams;" hence, my prior comment that turbidity measurements presented in Table 1 are "comparatively low for a discharge from a pond excavation site." In addition, a National Academy of Sciences Report (NAS 1972) prepared for the U. S. EPA includes the following statement ascribed to the European Inland Fisheries Advisory Commission: "there is no evidence that concentrations of suspended solids less than 25 mg/L have any harmful effects on fisheries." The NAS Report included the recommendation that aquatic communities should receive a "High level of protection" if the maximum concentration of suspended solids did not exceed 25 mg/L. Since the maximum recorded measurements of both turbidity and TSS did not exceed the limits described above, the most reasonable answer to the question posed at the beginning of the paragraph is no. And, if there was a downstream impact, it was limited both in time and space.

Were there any recorded violations of existing Massachusetts Water Quality Standards during the construction phase of the restoration project? The applicable narrative criterion in existing Massachusetts standards (Anon. 1983) reads as follows: turbidity and color "Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use." The most sensitive use was, and still is, "protection and propagation of fish, ... aquatic life and wildlife and recreation in and on the waters ..." In interpreting the "concentrations or combinations that would exceed the recommended limits," the Division would be guided by the following statements:

a) turbidity shall not exceed 25 JTU; and

b) suspended solids shall not exceed 25 mg/L nor shall the rise over background due to a discharge exceed 10 mg/L.

If statement "a)" is juxtaposed against turbidity data in Table 1, it becomes evident that the quality of water downstream of Dunn Pond at Stations 7, 8, and 9 would not be in "violation" of Massachusetts Standards on all sampling dates

during the supplemental monitoring period. Although one TSS value on August 23rd did equal the 25 mg/L stated in "b)" above, none exceeded this concentration. And this value is questionable. Thus, the same conclusion would apply. However, there were genuine increments of TSS)10 mg/L above "background" at Stations 7 and 8 on July 12th. Since these increments are consistent with turbidity data, it does indicate at least a limited "violation" of existing water quality standards at two stations that are proximal to the construction site (Fig. 2). The three other increments of TSS)10 mg/L above "background" in Table 2 (Stations 7 and 9) are disregarded since they both are inconsistent with other solids data recorded for the same date and they are inconsistent with turbidity data (Table 1). There were no other known water quality problems during the construction phase of this project. Therefore, it is reasonable to conclude from this analysis of the supplemental monitoring program that steps taken to mitigate the discharge of excessively turbid waters to Foster Brook were successful, that only a single violation of Massachusetts standards seems evident, and that this violation was limited in degree and distance downstream of the excavation site.

Finally, there was one relatively high measurement of TSS prior to Phase II construction at Dunn Pond. As reported in field notes, the 38 mg/L recorded for Station 8 on July 13, 1983 was caused during repairs to the emergency spillway at the dam. The repairs were completed on July 14th by R. Bates & Sons, Inc. of Clinton, Massachusetts under a short-term contract with the City of Gardner (personal communication with Arthur Young). The 38 mg TSS/L would have been considered a violation of Massachusetts standards in view of statement "b)" above. As noted elsewhere, this repair work was required as a pre-condition to the federal Section 314 grant.

Post-Construction Phase

Diversion of Stormwater

Did construction of the filtration dike and diversion of storm water drainage to Stump Pond serve to protect Dunn Pond from heavy loads of suspended solids? The answer to this question is an unequivocal yes. Post-restoration Stump Pond serves as a detention/retention basin for "approximately 75%" of the Dunn Pond watershed, as reported previously in Gardner/DEM (1983). There presently exists large sand/silt bars in Stump Pond that extend outward from both the 36 inch pipe draining areas west of Dunn Pond as well as the 30 inch pipe draining the eastern side. Obviously, the mass of most suspended particles in stormwater

runoff is sufficiently large that settling occurs quickly once flow subsides upon entering Stump Pond. But, what has been the fate of smaller-sized suspended particles, phosphorus, and stormwater that is discharged to Stump Pond? These issues are addressed in forthcoming paragraphs following a general discussion of the engineering hydraulics of Stump Pond, since the latter subject tends to confound the interpretation of monitored data.

Ideally, water is retained in Stump Pond for a sufficient time to facilitate stabilization and settling of "suspended" particles, both large and small. The dike was designed to retain and filter all water discharged to Stump Pond during a 1" rainfall, which includes 90% of the total annual stormwater flow in the Gardner area (Gardner/DEM 1982). Under this condition the surface of Stump Pond would gradually rise from 1103.5 feet to approximately 1106 feet as water is stored (about 5 acre feet). Retained water will gradually filter through the dike until the pond surface returns to 1103.5 feet. As noted below, however, fluctuations of this magnitude were not recorded, even following rainstorms of much greater magnitude.

The DEP measured water level elevations on both sides of the dike on thirty-six dates spanning a four-year interval when the ponds were monitored for water quality. Measurements were made from the tops of the headwalls of the 30 inch pipe (@ 1105.70 feet) discharging to Stump Pond and the twin 48 inch culverts (@ 1104.60 feet) hydraulically connecting the interbasin pool to Dunn Pond. Cross-dike differences in surface water elevations are listed in Table 3. The mean elevation of Stump Pond for the four-year, post-construction monitoring period was 1103.4 feet, nearly identical to the normal pool level specified in engineering documents (Gardner/DEM 1982). Most measurements were made during calendar years 1985 (N=13) and 1986 (N=14) when the mean water elevations of Stump Pond were 1103.4 feet and 1103.5 feet, respectively.

Stump Pond water level elevations exhibited little variation, however, ranging only from 1103.12 feet to 1103.91 feet. Also, and in contrast to project design, variations in its surface water elevation bear little resemblance to patterns of antecedent rainfall.[1] For example, the maximum recorded difference in water level elevations (0.83 feet recorded for July 23, 1986) was preceded by a period

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[1] All precipitation data referenced in this report were recorded by the Gardner Water Department for the Massachusetts Water Resources Commission (MWRC). The MWRC subsequently submits this same data to the National Oceanic and Atmospheric Administration for publication in periodic issues of New England "Climatological Data."

Table 3. Surface Water Elevations (MSL) of Stump Pond above that of the Interbasin Pool and the differences expressed in fractions of a foot.

Date of Measurement	Elevation of Stump Pond	Elevation of Interbasin	Difference in Elevation
Apr 13, 1985	1103.41	1103.18	0.23
May 07, 1985	1103.41	1103.23	0.18
May 23, 1985	1103.41	1103.14	0.27
Jun 03, 1985	1103.35	1103.08	0.27
Jun 19, 1985	1103.41	1103.10	0.31
Jul 02, 1985	1103.35	1103.10	0.25
Jul 15, 1985	1103.58	1103.18	0.40
Jul 30, 1985	1103.28	1103.08	0.20
Aug 13, 1985	1103.18	1103.06	0.12
Sep 04, 1985	1103.33	1103.10	0.23
Sep 23, 1985	1103.16	1103.06	0.10
Oct 21, 1985	1103.37	1103.10	0.27
Dec 10, 1985	1103.49	1103.14	0.35
Jan 28, 1986	1103.78	1103.52	0.26
Apr 09, 1986	1103.62	1103.18	0.44
May 28, 1986	1103.30	1103.10	0.20
Jun 11, 1986	1103.39	1103.18	0.21
Jun 24, 1986	1103.24	1103.14	0.10
Jul 09, 1986	1103.62	1103.10	0.52
Jul 23, 1986	1103.91	1103.08	0.83
Aug 04, 1986	1103.41	1103.14	0.27
Aug 20, 1986	1103.37	1103.16	0.21
Sep 09, 1986	1103.16	1103.06	0.10
Sep 29, 1986	1103.58	1103.14	0.44
Oct 28, 1986	1103.37	1103.25	0.12
Nov 25, 1986	1103.70	1103.31	0.39
Dec 29, 1986	1103.58	1103.27	0.31
Mar 19, 1987	1103.43	1103.18	0.25
May 12, 1987	1103.45	1103.18	0.27
Aug 04, 1987	1103.28	1103.10	0.18
Oct 01, 1987	1103.62	1103.18	0.44
Oct 26, 1987	1103.62	1103.10	0.52
Jan 25, 1988	1103.16	1103.10	0.06
Mar 21, 1988	1103.58	1103.10	0.48
May 02, 1988	1103.78	1103.27	0.51
Jul 14, 1988	1103.12	1103.02	0.10

of 9 days with no trace of precipitation and, on October 26, 1986, only 0.12 feet of stormwater was retained in Stump Pond (Table 3) following a rainfall of 1.01 inches. This translates to about 0.24 acre feet, which does not compare favorably to the design capacity of 5 acre-feet (or a 2.5 foot difference in elevation) following a 1 inch rainfall. Antecedent rainfall of 3.30 inches in a 48 hour period prior to January 28, 1986 resulted in a cross-dike water elevation of only 0.26 feet. Although the elevations on the Stump Pond side of the dike were invariably higher, the cross-dike differences never exceed 1 foot (Table 3).

That the dike has not retained larger, and predicted, volumes of stormwater following major rainfall events cannot be explained in terms of erroneous runoff estimates, improper measurements of cross-dike water levels, the filtration capacity of the dike itself, or a combination thereof. Rather, the most plausible explanation is that a portion of stormwater runoff bypasses the dike by way of the riser pipe spillway, or vertical culvert. This device was included in the design plan for the purpose of draining Stump Pond should the dike need to be maintained or repaired (personal communication with Carlos Carranza of BEC, Inc.). The spillway is located in the Pond and it cannot be inspected without launching a boat, so its condition was not monitored routinely. It appears certain, however, that the stoplog structure within the riser pipe was not set to retain more than 1 foot of stormwater, perhaps as a consequence of vandalism. Likely there have been many occasions since the completion of the restoration project when a portion of stormwater inflow bypassed the dike via outflow through the riser pipe spillway, thereby loading solids and nutrients to Dunn Pond that should otherwise be retained. The stoplog setting of the riser pipe needs to be set securely at 1106.0 feet, as designed, to achieve maximum water quality benefits with no apparent risk of flooding.

The retention of larger-sized suspended particles from stormwater runoff was achieved, as discussed previously, but what has been the fate of smaller particles? Visual inspections of both Stump Pond and Dunn Pond by DEP staff revealed no obvious differences in turbidity during the four-year long monitoring program following construction activities. However, the mean concentrations of TSS on the Stump Pond (Station 3) and Dunn Pond (Station 6) sides of the filtration dike were different (4.0 and 2.5 mg/L, respectively). These data represent 38 sampling events (Appendix VI). On 27 of these events (or 71%) the concentration of TSS was higher on the Stump Pond side of the filtration dike, whereas there was essentially no difference (less than 1 mg/L) on 7 sampling dates (or 18%). Although the gravimetric method of determining TSS is subject to interference and errors, especially at such low concentrations, it is reasonable to conclude that the Stump Pond system effectively retains finer suspended

particles either through eventual precipitation or as water percolates through the sand layer of the filtration dike. Exceptions would occur when stormwater bypassed the dike as noted previously.

The dike-filtered water pools on the north side of Pearl Street (Station 6) before it flows to Dunn Pond through the twin 48" culverts. The TSS data recorded for Station 6 (mean = 2.5 mg/L; range = N.D. - 7.0; N = 38) is nearly identical to that recorded for the surface water (Station 1) of Dunn Pond (mean = 2.2 mg/L; range = N.D. - 8.5 mg/L; N = 37). This is an expected outcome since there is comparatively little direct input of TSS to Dunn Pond subsequent to its restoration. Also, Dunn Pond does not support dense populations of phytoplankton, which otherwise would skew the TSS data at Station 1 relative to Station 6. The TSS content of water collected at Station 6 might have been higher on those occasions when stormwater bypassed the filtration dike by way of the riser pipe spillway prior to or during sampling. However, the range of TSS noted above for this station is not indicative of any serious deviation.

Other than direct stormwater discharge, what is the relative watershed load of TSS to Stump Pond? Despite the large ratio (approximately 250:1) of its natural drainage area to its water surface area, annual discharge to Stump Pond from its two tributaries (Stations 04 and 05) is likely quite small. DEP staff were not able to collect water samples at these two stations on nearly half of the monitoring surveys, and insufficient flow is often recorded on field notes as the reason. And, when measured, the concentrations of TSS for Station 4 (range = N.D. - 7.5 mg/L; mean = 2.3 mg/L; and N=18) and Station 5 (range = N.D. - 12.0 mg/L; mean = 3.2 mg/L; and N = 19) were low.

One grab sample collected at Station 4 on July 2, 1985 contained 36.0 mg/L TSS. This datum is highly suspect since the corresponding value at nearby Station 5 on this same date is only 1.0 mg/L, and these two "brooks" typically exhibited similar concentrations of TSS. This extreme, or "outside," value is considered to be the result of a sampling error and it was not included in the derivations of mean and range concentrations listed in the previous paragraph for this station. Most likely, resuspended sediments were drawn into the bottle during collection of this grab sample under low flow conditions.

The "natural" loading of TSS to Stump Pond from its watershed was likely of no major consequence during the period of the monitoring program. Further, since Stump Pond is small, circular, and protected from prevailing winds, resuspension of in-pond particulate matter is not a likely explanation for its higher TSS content. It is more probable that the higher concentration of TSS on the Stump Pond side of the filtration dike reflects the fines from the two stormwater systems that drain Pearl Street and Betty Spring Road.

Whether "the combination of sedimentation and filtration removes ... about 90% of the total suspended solids" that entered Dunn Pond prior to the restoration project as predicted (Gardner/DEM, 1982) remains unknown since there is insufficient information to make that determination. For example, there is a complete lack of historical data on loading of TSS to Dunn Pond prior to restoration. Also, any such assessment is confounded by the likelihood that some stormwater inflow to Stump Pond bypassed the filtration dike. The Division's Limnology Group did conduct a post-project survey and inspection of the Dunn Pond restoration site on July 18, 1991. At that time there were only two points where obvious erosion and suspension of solids discharged directly to Dunn Pond (Fig. 2): a) from the unpaved parking lot on the south side of Pearl Street and west of the twin 48" culverts; and b) along the old roadbed, also south of Pearl Street, but east of the culverts. The latter is more serious and it has resulted in some loss of water volume at the northeast cove. Since Stump Pond now serves as a detention/retention basin for "approximately 75%" of the Dunn Pond watershed (Gardner/DEM 1983), it is reasonable to conclude that the combination of sedimentation and filtration that occurs in this pond does remove most of the TSS load that would otherwise be discharged to Dunn Pond.

As noted elsewhere in this report, the Massachusetts Department of Environmental Management (DEM) has assumed management of Dunn Pond and Dunr Park. The Division of Water Pollution Control's Limnology Group has formally notified the DEM Pa.. Superintendent through a letter of correspondence (Appendix XI) about the two aforementioned sites of erosion and the need to control this direct input to Dunn Pond. The Division's letter also included a "reminder" that routine maintenance to remove excess deposits of sediments at Stump Pond was wanting. In fact, the sand bar in front of the 30 inch drain pipe headwall had slowed flow sufficiently that suspended solids were being deposited within the pipe. Also, there was evidence that the filtration dike was not being maintained and there existed the potential that the Stump Pond face of the dike might become "plugged" by a mat of organic matter (including aquatic vegetation, algae, and associated benthic community). For these reasons the "Recommendations for Filtration Dike Maintenance Procedures" developed by BEC, Inc. was attached to the aforementioned letter.

The Limnology Group's letter to the DEM Park Superintendent did not mention the need to control the riser pipe stoplogs since this issue only became evident following my analysis of the project data in June 1993. Based on the information presented above, however, it is evident that the Department of Environmental Management needs to develop a comprehensive management plan for these two ponds, including regulation of Stump Pond elevation and maintenance of the dike.

Reduction of Total Phosphorus Load

It was previously estimated (Gardner/DEM, 1982) that the combination of "sedimentation and filtration" would also effectively remove "about 70% to 90% of [total] phosphorus" that entered Dunn Pond prior to the restoration project. As with TSS, however, the percent reduction of the phosphorus load cannot be estimated since there is no known database that can be employed effectively to calculate loading prior to restoration. However, the mean concentrations of total phosphorus measured across the filtration dike were substantially different. These were, respectively, 70 μg/L recorded for Stump Pond (Station 3) and 40 μg/L for the interbasin pool (Station 6). Sixty percent of the cross-dike Total P measurements were higher at the Stump Pond site, whereas there was essentially no difference in 24% of the 37 sets of samples. Three of 74 Total P samples were reported to contain less Total P than the detection limit of 20 μg/L. For the purpose of calculating mean concentrations I assumed the worst case for these three samples; that is, 20 μg/L. The two tributaries at Stations 04 and 05 do load some phosphorus to Stump Pond, but the percent contribution is likely quite small. The mean concentration for both brooks was identical, 50 μg/L, based on 19 sample sets.

Since there was no difference in the mean concentrations (40 μg/L) of Total P between the interbasin pool at Station 6 and in Pond Station 1, it is reasonable to conclude that the sand layer of the filtration dike does effectively remove phosphorus from both stormwater and tributary inflow, as designed. Again, the assumption presented in this report is that the interbasin pool represents dike-filtered water.

Dunn Pond Restored

Morphometry

The condition of Dunn Pond upon its refilling in early April 1985, and for four subsequent years, is revealed in Appendix VII data. In terms of its morphometry, Dunn Pond was virtually restored to its former kettlehole shape since sediments and peat were excavated to the depth of post-glacial deposits. Exceptions include the south end of the pond, mentioned previously, and the "deep hole," where some peat deposits were beyond the effective "reach" of the contractor. The new shape is presented in Figure 3, and further reference to "Dunn Pond" in this section of the report pertains to the bathymetry shown in that figure.

Thermal Regime

Of course, Dunn Pond today is vastly different in many ways from its recent (early 1980's) predecessor; the excavation of more than 230,000 cubic yards of sediment and peat deposits assured that this would be true. Other than the fact that it is now an open body of water in contrast to a near marsh, the most striking difference is the complete change in the physical regimen from a more-or-less continuous, wind-induced stirring of a shallow waterbody during the ice-free months to "dimixis," with only two intervals of water column circulation per annum, in the spring and fall months. During the intervening periods, that is summer and winter, the Pond exhibits thermal stratification, which is the predictable outcome of a vastly increased water volume and mean depth. The diversity of Dunn Pond habitat has increased accordingly.

The stratification recorded for Dunn Pond is not of the classical pattern, or a well-developed warm epilimnetic stratum overlying a transitional thermocline stratum overlying a well-developed cool hypolimnetic stratum. Exceptions are noted, however, such as June 3, 1985 and June 24, 1986. Typically, most of the summer water volume in Dunn Pond exhibits $\geq 1°$ centigrade change in temperature per meter depth in the water column (Appendix VII), which defines a thermocline. In contrast, the volume of the hypolimnion is small; its depth rarely exceeded 2 meters. Although the mid-summer volume of the epilimnion was quite variable over time, it was often delimited to about 1 meter (approximately 60 acre-feet) and sometimes absent altogether.

The explanation for these seemingly peculiar phenomena rests in part with the high concentration of dissolved organic compounds characteristic of Dunn Pond water. These organics reduce substantially the amount of subsurface radiation, and they shift the spectrum of this radiation in a profound manner. In a clear lake - one with low concentrations of dissolved organic matter and suspended solids - infrared, red, orange, yellow, green and blue wavelengths of radiation excite water molecules, thereby converting the energy of radiation to heat, which warms the water. However, the percent absorption of these various wavelengths is not uniform; rather, it grades from very high for infrared wavelengths to very low for blue wavelengths. Since blue and green wavelengths are least absorbed by water, it is this radiation that is scattered back to the surface of clear lakes, rendering various combinations of those colors to the onshore observer.

Dunn Pond appears dark, even black, to the onshore observer since most of the radiation impinging on this water body is absorbed. Upon close examination Dunn Pond appears tea colored. This means that certain yellow and red wavelengths are being scattered by suspended and dissolved organics rather than absorbed by water molecules. Likely, it also means that there is a high

concentration of ferric iron bound to these molecules since "Colored water usually contains higher iron ... concentrations" (Stumm and Morgan 1981). Ultraviolet, blue, and green wavelengths of subsurface radiation are strongly absorbed by dissolved organic acids, probably within the top few feet of Dunn Pond. Infrared, especially, and red wavelengths are absorbed primarily by water at shallow depths, which accounts for surface warming of most waterbodies. Thus, to an extent beyond that in comparatively clear lakes with low concentrations of dissolved organic compounds, the warming of Dunn Pond is confined largely to the top few feet of the water column. First-time swimmers to the Pond have uttered various shrieks to express their discovery of this physical phenomenon. Wind-induced movement of this warmer, less dense surface water to lower depths is likely limited given the "protection" offered by Reservoir Hill to the northwest, and Bickford and Parker Hills to the west and southwest (Fig. 1).

The first *in situ* monitoring of Dunn Pond was conducted on April 23rd, 1985, shortly after it had been refilled. As described above, near-surface warming of water was quite evident. The surface temperature was 13.7°C and this remained unchanged at the 1.0 meter depth, but water temperature declined abruptly to 9.9°C at 2.0 meters. As the upper water column warmed slowly over the summer months the deepest water at Station 1 remained cool. Temperatures recorded at both 6.0 and 7.0 meters increased less than 2°C during the summers of 1986 and 1987 (Appendix VII). These low temperatures indicate no direct conversion of subsurface radiation to heat and little wind-induced circulation of the water column to this depth during the spring months. In turn, these conditions lead to low concentrations of dissolved oxygen recorded for the hypolimnion. Typical concentrations were less than 5 mg/L, and complete anoxia was recorded on two occasions (October 1, 1987 and August 1, 1989). The depletion of oxygen within this stratum most likely resulted from the decomposition of organics by the microbial food web. The lower-most depths at Station 1 also became anoxic for a two month interval after the Pond was refilled (Appendix VII), but this may only reflect a period of disequilibrium since oxygen was restored to the hypolimnion by mid-summer.

Hydrochemistry

As discussed previously under Pre-Construction Monitoring, the natural drainage to Dunn Pond is quite acidic. All in-pond pH measurements recorded during the first month upon refilling were less than 4.0 units, as were those for Stations 4 and 5. And two-thirds of 302 post-construction pH measurements recorded for Station 1 were less than 5.0 units. However, over time there was a gradual, and somewhat inexplicable, increase in pH not only at Station 1, but at Stations 4 and 5 as well (Appendices VI and VII). There was also a corresponding gradual

increase in total alkalinity over time, particularly at Station 1. I did investigate the possibility that Living Lakes, Inc. may have applied limestone to neutralize Dunn Pond and/or its watershed. Donald Porcella of the Electric Power Research Institute communicated to me that this had not occured after he kindly checked the archived records of the now defunct Living Lakes organization.

Post-construction specific conductance (also conductivity, a measure of the "total amount of ionized material" in water) data have been summarized in Fig. 8. Data used to construct this figure have been limited to those dates in which information was available for Stations 4 and/or 5 as well as Stations 3, 6, and 1 (Refer to Appendix VI). These sampling sites represent, in a sequential manner, the feeder brooks to Stump Pond, Stump Pond proper, the interbasin pool, and Dunn Pond surface water. Not surprisingly, the ranges 2of conductivities for stations 4 and 5 are essentially identical. At each sequential station, however, the range increases despite considerable overlap. At 113 to 220 μmhos/cm, Dunn Pond surface water exhibited almost twice the conductivity of the two brooks draining to Stump Pond even though these three sampling sites are proximal to one another.

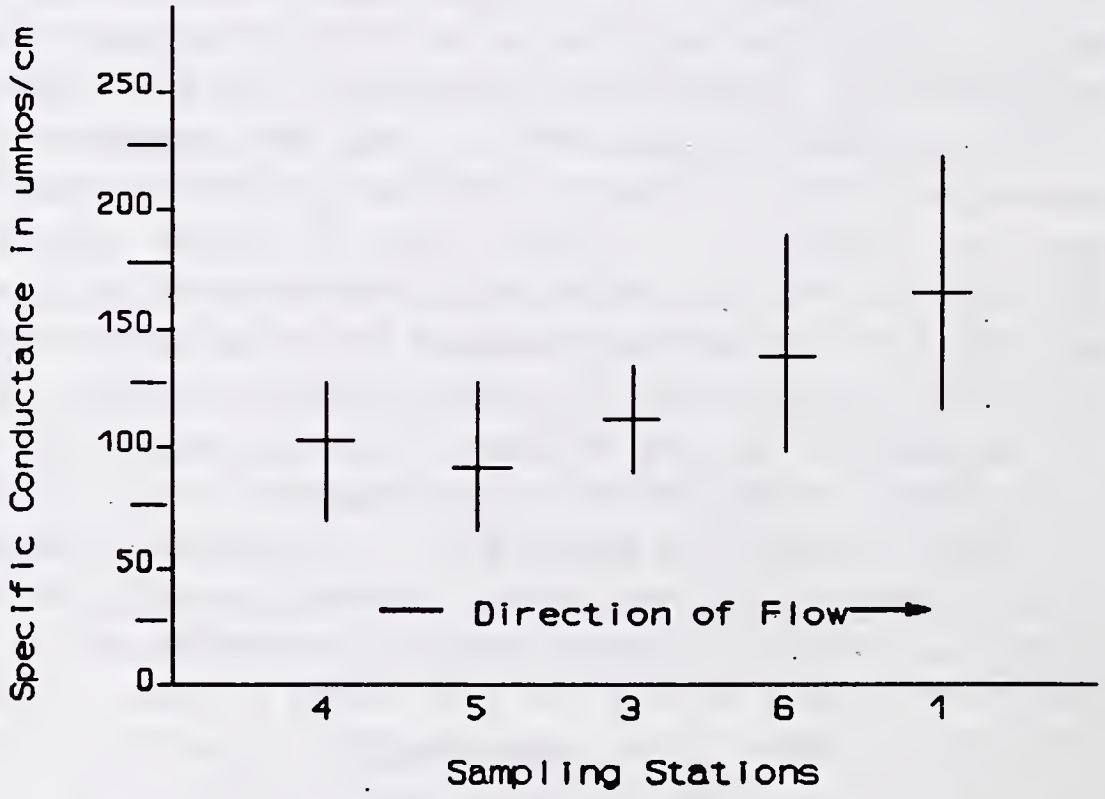

Fig. 8. Range and Mean (bar) Conductivities of Surface Water at Selected Stations recorded between April 23, 1986 and May 21, 1986.

There are probable and reasonable explanations for these results. In a stepwise manner, the "natural" drainage discharge to Stump Pond from its tributaries periodically receives, and mixes with, stormwater runoff from Pearl Street and Betty Spring Road (described previously). To my knowledge there are no data available on the range and mean conductivities of these episodic discharges, but their potential effect on the water chemistry of Stump Pond is likely considerable given the relatively large ratio of storm drainage area to Stump Pond surface area. The 10% and 20% increases in mean conductivities above that of Stations 4 and 5, respectively, is, therefore, not unreasonable. So too is the 25% increase in mean conductivity as Stump Pond water filters through the dike between this station and the interbasin pool at Station 6 (Fig. 8). The materials used in constructing the filter dike (sand, peastone, crushed stone, rockfill, and rip rap) may have released various water-soluble ions during the slow process of percolation. At 163 μmhos/cm, the mean conductivity at Station 1 is elevated 18% above that recorded for the interbasin pool. In this instance the sources of ions are less obvious, and there is only a small sub-area of the watershed draining directly to Dunn Pond in its restored state. Probable sources of ion contribution include exposed post-glacial deposits subsequent to excavation of overlying sediment, runoff from the gravel parking lot bordering the northwest perimeter of the Pond, and runoff to the northeastern cove from the old road bed and parking area. Another possible source is water emanating from "springs," especially along the northeast cove area below Betty Spring Road.

The vertical profiles of conductivity at Station 1 (Appendix VII) indicate strong gradients, with a four- to six-fold greater ionic content measured at the 7 meter depth than recorded for the surface. This pattern was established by May 7, 1985, shortly after the pond was refilled, and it continued until the spring of 1987. To a considerable degree this pattern was maintained irrespective of the thermal mixing state of the water column; that is, summer stratification, inverse winter stratification, or near holomixis. Further evident in Appendix VII are more-or-less uniform profiles of conductivity in the upper water column within strata of uniform temperatures. However, at lower depths there often were significant differences in conductivity per vertical meter in a water column that also exhibited near uniform, but much colder, temperatures. These results are somewhat puzzling since the Division's *in situ* conductivity measurements are automatically compensated for differences in temperature.[2] Also, on each

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[2] Although "conductance increases about 2 per cent per °C," the Hydrolab© Digital 4041 unit automatically compensates all conductivity measurements to their equivalent values at 25°C, which is the international standard reference that is widely used in limnological investigations (Wetzel 1975).

sampling date, the Hydrolab field unit was calibrated to potassium chloride standards at 719 μmhos/cm and 147 μmhos/cm, which is precisely the range for the vast majority of measurements recorded at Station 1. Thus, an explanation for this peculiarity of Dunn Pond does not rest with the instrument used to generate the data.

My conviction is that the profiles of measured conductivity at Station 1 do represent strong vertical gradients, which is likely the consequence of a vast pool of dissolved, colloidal, and suspended organics derived from the incomplete decay of aquatic plants. No doubt the excavation of peat and sediments, plus the swirling eddies of water during refilling, contributed large amounts of low molecular weight organics and large, refractory lignocellulose particles to the water column. The latter is a "macromolecular complex consisting of polysaccharides (cellulose and hemicellulose) and lignin in intimate physical and probably covalent contact" (Hodson et al. 1985). These authors further claim that "most of the annual primary production in wetland ecosystems is in the form of lignocellulose."

Among this mixture of molecules, dissociated organics would increase the conductivity beyond that of the common ions since "the -COOH radical is abundant" (Cole 1983). In addition, and as reported by Cole, these humic substances can complex, or chelate, metallic ions such as ferric iron, further contributing to the conductivity of water. Hem (1986) reported that the concentrations of iron in water "generally are small," even though it is "the second most abundant metallic element in the Earth's outer crust." For most neutral or alkaline lakes, Wetzel (1975) lists a range of total iron from 50 to 200 μg/L (0.05 to 0.20 mg/L), but he acknowledges that "much higher levels occur in lakes heavily stained with dissolved limnohumic compounds." And, at 1 mg/L, the total iron recorded for the Dunn Pond system in a 1979 Division survey was much higher. Lower molecular weight organics are more soluble and they chelate up to six times more metal ions than heavier compounds (Cole 1983). This is consistent with the 1.4 mg/L total iron reported by Hem (1986) for a stream in northern Minnesota "with a large amount of dissolved organic material." It is the lower molecular weight organics that also absorb blue and green wavelengths of subsurface radiation, as I have described previously, further contributing to the tea color of Dunn Pond water.

What remains to be explained are the strong vertical gradients of conductivity that prevailed for two years following the restoration of Dunn Pond. It is quite probable that the mass of soluble, colloidal, and suspended organics were concentrated near the bottom of the water column. Tests for heavy metals by the Division on April 9th, 1986 lends credence to this suggestion. That is, 0.4 mg

total iron/L was recorded for the surface at Station 1 on this date, whereas at 7 meters iron increased twenty-fold to 8 mg/L. Similar measurements for manganese (0.09 and 0.61 mg/L, respectively) and aluminum (0.26 and 1.2 mg/L, respectively) are less impressive, but they too are consistent with my vertical gradient hypothesis. These results cannot be explained as the consequence of either solution under anoxia, since the lowest recorded concentration of dissolved oxygen was 4.3 mg/L at the 7 meter depth on this date, or pH, which was much higher at the pond bottom (Appendix VII).

Since there was a markedly greater concentration of heavy metals at depth, and no doubt dissolved and suspended organics as well, the specific gravity of water would have been increased accordingly. This chemical-induced density of water differs from temperature-induced density that accounts for thermal stratification regimes in most "deep" lakes and ponds, but it would be entirely consistent with some peculiarities of stratification at Dunn Pond that I have discussed previously. For example, the wind-induced downward movement of less dense surface water typically displaces denser bottom water in thermally stratified lakes during the spring and fall mixing periods, but the chemically dense bottom water at Dunn Pond would offer even greater resistance to such displacement.

Although hypothetical, the aforementioned description of events also explains the strong vertical gradients of conductivity that were recorded somewhat irrespective of thermal stratification, and it further explains why bottom water did not warm more than 2°C during the summer months. Of course, the emanation of "spring" water at the deep area of the west cove is another possibility, but one that is difficult to support given the relatively high conductivities measured at depth. However, the upwelling of spring water may have contributed to the resuspension of organics at depth, so these two explanations are not mutually exclusive.

The top-to-bottom gradient in conductivity at Dunn Pond began to diminish in 1987 from a four- to six-fold difference to generally less than three-fold. The surface and bottom (7 meters) conductivities recorded in a follow-up survey on July 18, 1991, six years after Dunn Pond was refilled, were 119 and 176 μmhos/cm, respectively, a ratio of only 1.4:1. The reason(s) for this recorded change remain obscure although it may be related to subsidence of spring water emanating at depth and, perhaps, a restoration of equilibrium. It is sufficient to state that past biogenic production at Dunn Pond and within its watershed do result in subsequent, and significant, effects on its chemical and physical regimes. And this is why Dunn Pond is somewhat peculiar.

Macrophytes

Since Dunn Pond was dry for several years during construction of the interceptor sewer, the September 1979 survey of macrophytes (aquatic plants) by the Division of Water Pollution Control's Technical Services Branch is the most recent source of information prior to the restoration project. The degraded condition of the Pond at this time has been described elsewhere in this report. Acid-tolerant macrophytes grew profusely in the shallow, warm water as indicated in Fig. 9. Dense populations of water milfoil (Myriophyllum sp., likely M. humile (Raf.) Morong), bladderwort (Utricularia radiata Small), a thin-leaved pondweed (Potamogeton sp.), yellow water lily (Nuphar variegata Durand) and bur reed (Sparganium sp.) accounted for most of this plant biomass. Post-construction macrophyte surveys were conducted annually during each summer from 1985 through 1988. Also, a follow-up survey was completed by the Division on July 18th, 1991. Maps of percent cover by macrophytes for each of these years are included in Appendix VIII; that of the most recent 1991 survey is presented in Fig. 10.

On August 13th, 1985, only a few months after Dunn Pond was refilled, the community of macrophytes had been reestablished, but not in terms of biomass. Among thirteen recorded species populations, Myriophyllum humile, Potamogeton bicupulatus Fernald, and Utricularia radiata were common, as was Sparganium sp. The latter plant was listed as Vallisneria americana Michx., but this is surely a misidentification of Sparganium, which was recorded in all other surveys described above. The coverage by the macrophyte community was moderate (approximately 25 to 50%) at the southeast area of the Pond, an area not subject to extensive excavation as a means to mitigate damage to the entire littoral community. Portions of the western perimeter of the Pond, and of its single island, also exhibited moderate coverage by macrophytes.

The density of macrophytes began to increase gradually in the aforementioned zones over the next three summers, beginning in the protected coves and then along the Pond margins (refer to percent cover maps in Appendix VIII). However, following a rather thorough survey of the macrophyte community in 1991, it was evident that the initial spread of plants in the southeast area and along the western perimeter of Dunn Pond had changed. These areas were now sparsely populated except for two coves and the margin of a peninsula near the dam. Conversely, plant density had increased along the east margin (Fig. 10). In terms of frequency of occurrence, the most common plants were M. humile, P. bicupulatus, and N. variegata (Appendix VIII). The occurrence of thirteen other species populations are included in Appendix VIII as well. Potamogeton epihydrus Raf., a common submersed plant of acid ponds in Massachusetts, stands out among these other plants because it was not listed in surveys prior to

FIGURE 9

PERCENT COVER BY MACROPHYTES PRIOR TO RESTORATION. SEPTEMBER 13, 1979

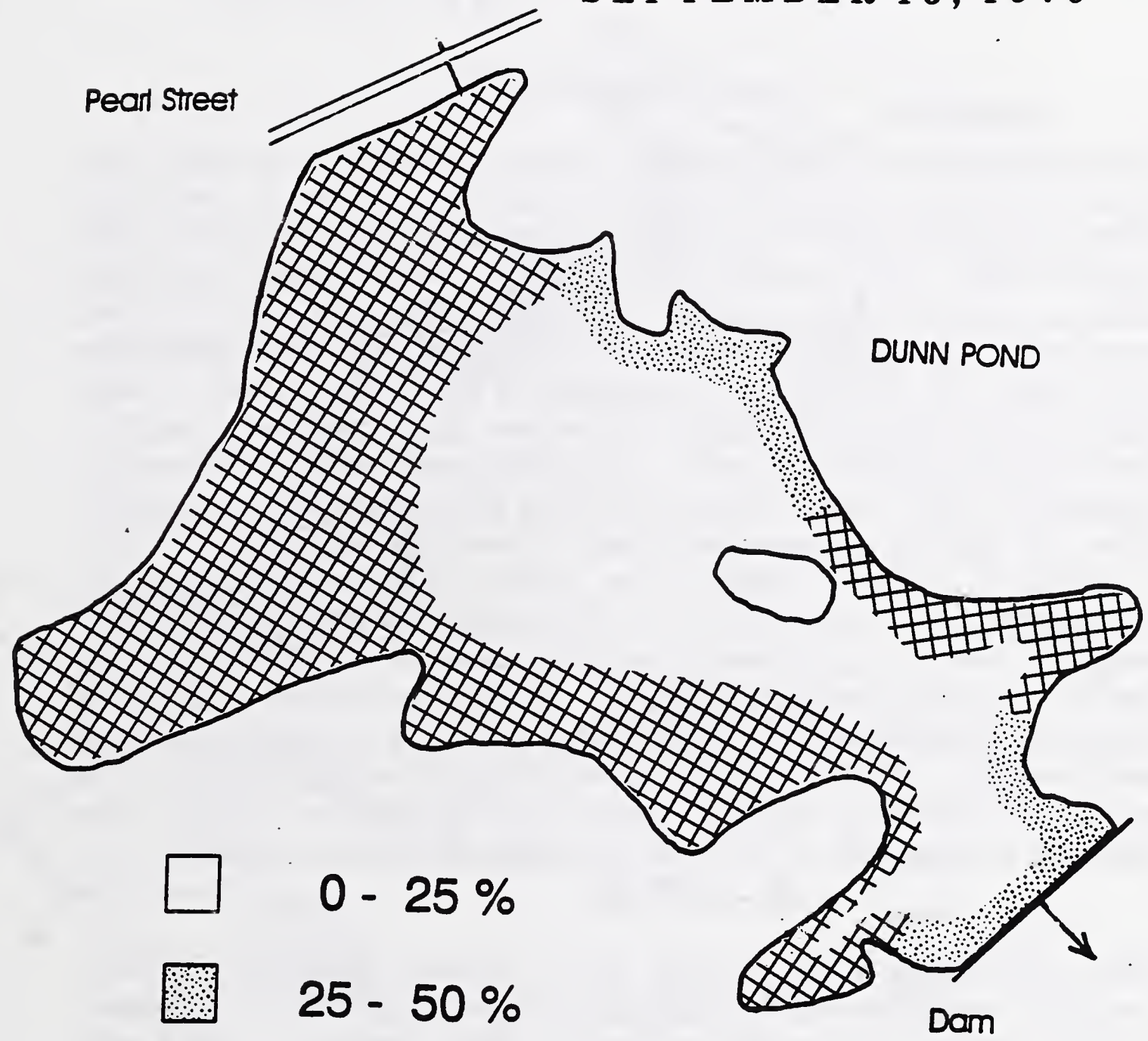
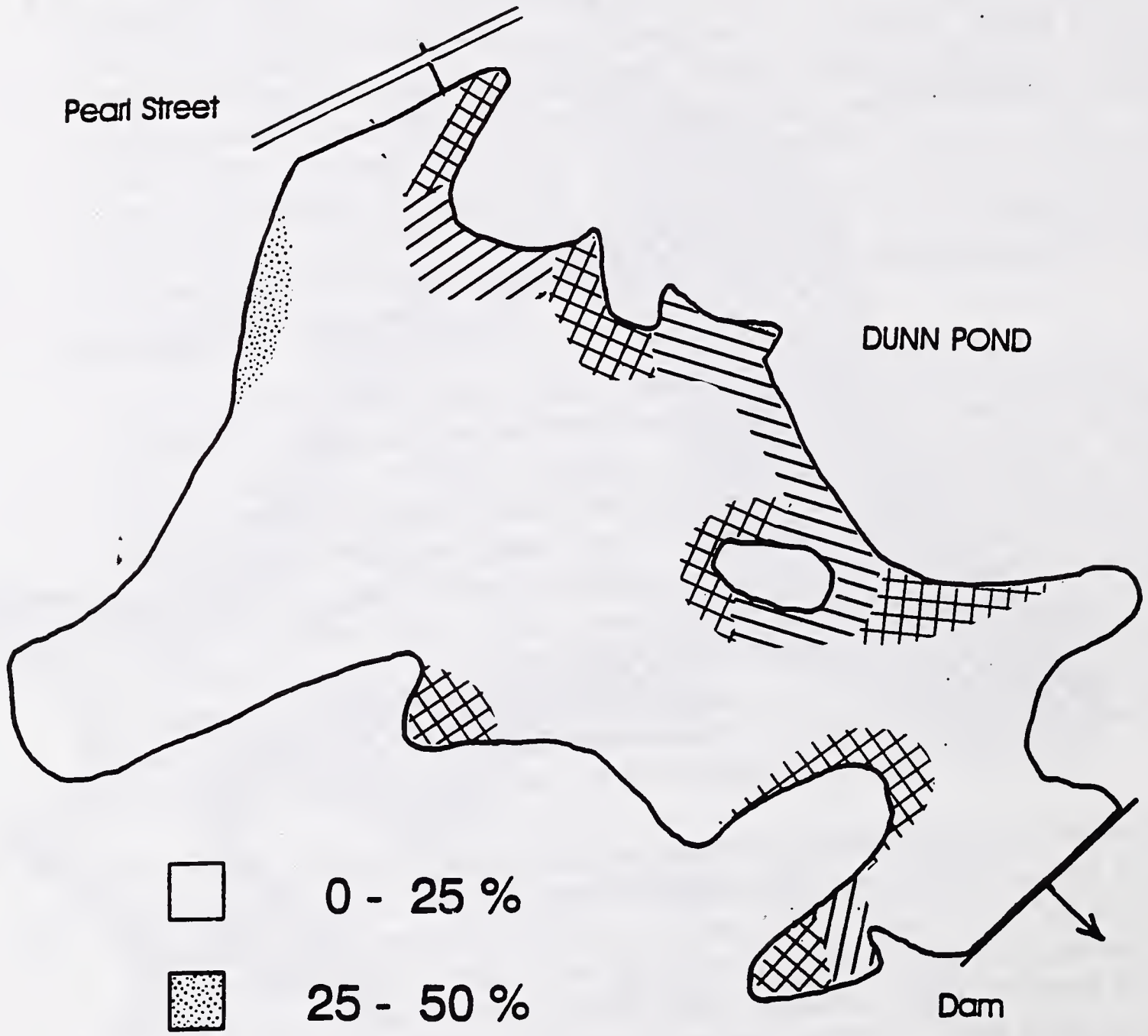


FIGURE 10

PERCENT COVER BY MACROPHYTES FOLLOWING RESTORATION. JULY 18, 1991



July 23rd, 1987, yet its population increased following that survey to a 17% frequency of occurrence by 1991.

It is important to note that neither the macrophyte community nor any of its composite species populations constituted a nuisance at Dunn Pond subsequent to its restoration. In fact, the contrary would likely be true. The macrophyte community probably provided a sustainable habitat for periphyton and the littoral invertebrate community so important to the Pond's developing fishery.

Phytoplankton

Dunn Pond's phytoplankton community might be considered impoverished based on analyses of twenty-five samples collected at Station 1 over a four-year period (1985 -1989). The phytoplankton community was neither enriched with species populations nor productive in terms of its biomass. The free-swimming, dendroid-like colonies of the chrysophyte Dinobryon were the most commonly recorded phytoplankter. This is instructive since "Dinobryon is ... almost never found in waters with a high concentration of phosphorus" (Lee 1980). Lee explains further that at high concentrations of phosphorus other phytoplankters outcompete the slow-growing Dinobryon. At low concentrations, however, cells of Dinobryon colonies sequester phosphorus more efficiently. Thus, the common occurrence of this phytoplankter at Dunn Pond might indicate that little of the total phosphorus pool was available, and/or rapidly cycled, as phosphate. A further indication that this might be true is the low production by phytoplankton in a pond exhibiting a moderate-to-high mean concentration of total phosphorus (40 μg/Liter measured at Station 1). And, "Dinobryon uses phosphate not only as inorganic phosphate but also as organically bound phosphate in moderate-sized molecules..." (Lehman 1976, as cited in Lee 1980). This is typical of some other flagellates recorded for Dunn Pond as well and, in concert with the large pool of dissolved organics, it probably accounts for the dominance of flagellated phytoplankters.

Conversely, Professor Bomchul Kim of Kangwon National University, South Korea, has reported (personal communication) that dissolved humic substances from wetland and littoral plants can combine with proteins on the surfaces of algal cells and thereby inhibit these molecules. And, if the surface protein was the enzyme alkaline phosphatase, then the ability of phytoplankters to derive phosphate from organic molecules would be inhibited. I have discussed elsewhere in this report the importance of the previously-produced pool of organic molecules in governing the chemical and physical regimes at Dunn Pond, and it is evident from my discussion above that these same organics probably affect the plankton community as well.

In addition to colonies of Dinobryon, single-celled flagellates in the genus Mallomonas (a chrysophyte) and Cryptomonas (a cryptophyte) were commonly identified. Diatoms were detected in phytoplankton samples on occasion, especially Synedra, but sometimes Fragillaria, Tabellaria, and Melosira were enumerated as well. Also, the desmids Closterium and Staurastrum were evident in a few samples. The technician that identified and counted phytoplankters recorded that no cells, colonies or filaments could be detected in some samples, even concentrated samples. Chlorophyll data provide an index of phytoplankton biomass, and chlorophyll is more quantitative and more instructive than counts of cells, filaments, and colonies of the various species populations. For example, seventeen of twenty post-restoration assessments of phytoplankton chlorophyll were ≤ 3 μg/L, which is typical of concentrations recorded for oligotrohic lakes (Wetzel 1975). The 98 μg chlorophyll/L recorded at Station 1 on June 11, 1986 is most assuredly an error, since this value would be high for North American lakes in general, and it would be clearly visible to the onshore observer as a "bloom." No such observation was recorded on the field sheet for this date, and the subsequent enumeration of phytoplankton populations was not extraordinary. The impoverished community of phytoplankton that characterizes Dunn Pond is ultimately the consequence of dissolved organic acids. These compounds limit subsurface radiation, especially in the blue wavelengths so essential for photosynthetic production, and they further limit the availability of phosphate phosphorus, a nutrient so essential to metabolic processes in living cells.

Fishery

The Massachusetts Division of Fisheries & Wildlife postponed restocking Dunn Pond until the spring of 1987. At that time 250 eastern brook trout (Salvelinus fontinalis Mitchell) were introduced for "put-and-take" sport fishing. The spring stocking rate has been increased gradually since 1987 as indicated in the tabulation below, and MDFW's long-term objective is to stock 1300 - 1500 trout annually (personal communication with Lee McLaughlin).

Year	Eastern Brook Trout
1988	500
1989	550
1990	600
1991	600
1992	900
1993	1100

The average length of most stocked trout is 9 inches although some exceeded 12 inches. A further 1222 trout averaging 6 inches were added in the fall of 1993 to relieve overcrowding at one of the fish hatcheries, but this will not be routine practice. The current composition of warm water species populations cannot be listed since the last fishery survey by MDF&W was completed before Dunn Pond was restored. Largemouth bass, yellow perch, bluegill sunfish, and brown bullheads are known to inhabit the restored Pond, but they were not introduced by officials empowered to do so (personal communication with Lee McLaughlin).

THE PURSUIT OF RECREATION AT DUNN POND

The restoration of Dunn Pond and its environs has had a profound effect on regional recreation, and it has become especially attractive to urban residents of Gardner. Therefore, I asked Park Supertindent Dorothy Zug to document these activities, and her informative letter is included in Appendix XI. Most extraordinary is the increase in park attendance from 14,892 in 1987, " when the park was reopened and swimming was first available," to 48,964 in fiscal year 1993. This reflects a 230% increase during this six-year interval. Pond activities have included swimming, sport and pan fishing, non-motorized boating (paddleboat, kayak, canoe), log rolling, and ice skating. Fishing derbies typically draw "600 - 1000 people, depending on weather," and about 500 people participated in an ice skating party last winter. A scenic exercise trail, picnic area under the trees, playground, and programmed activities also draw regional citizens to the park. Other information in Superintendent Zug's letter further attests to the recreational benefits of restoring this site.

CONCLUSIONS AND RECOMMENDATIONS

Dunn Pond is an exemplary restoration project for many reasons. Foremost among these is the present condition of the Pond, which is vastly improved when compared to its degraded state in the early 1980's. It is much deeper now and there is greater diversity of pond habitat as a consequence. Its cold water habitat, stocked with trout for sport fishing, is a sterling example. This was not possible in the shallow ponds previously occupying this site over the past century. Dunn Pond's water is "clean" despite its tea color - a characteristic of other lakes and ponds in the upper central plateau of Massachusetts - and it is safe for both contact and non-contact recreation. The Pond does exhibit some other peculiar attributes based upon its location and past history, but these are only evident upon close scientific examination. This scenic and aesthetically pleasing "jewel in the landscape" is located less than two miles from the City of Gardner center, which renders its restoration even more commendable.

This restoration project is exemplary also because the problems that led to the degradation of the previous pond have been addressed and corrected. The diversion of stormwater to Stump Pond and construction of the filter dike are prime examples because these modifications serve to prevent the discharge of sediments, nutrients, and other "pollutants" directly to Dunn Pond. If maintained properly, the Stump Pond facility can protect Dunn Pond long into the future, which should be the goal for any carefully planned lake and watershed management project. Also, the total expenditure of funds to complete this project ($1,263,891.26) is not extraordinary given the extent of the restoration work, the quality of the restored Pond, and the long-term prospects for the Pond to sustain more varied and more intensive use by the public.

Since "the long-term prospects" for Dunn Pond are fully dependent on facilities constructed at Stump Pond, I can make no stronger recommendation than the proper and timely maintenance of these structures, irrespective of their ownership. Present ownership of Dunn Park rests with the City of Gardner; however, pursuant to Chapter 656 of the Acts of 1983, conveyance of this parcel of park land to the Commonwealth's Department of Environmental Management (DEM) is imminent once title examinations are completed. DEM should give high priority to the acquisition of Stump Pond and bordering properties that are not presently included in the parcel of park land noted above. Control of the Stump Pond property is imperative since the filter dike must be cleaned and maintained routinely according to recommendations set forth in Appendix XI, and this has not occurred to date. Of equal importance is control of the riser pipe spillway elevation at 1106.0 feet (MSL), as designed, to eliminate unnecessary loading of suspended solids and nutrients to Dunn Pond. Also, catch basins in the Stump Pond drainage area need to be cleaned routinely since they serve to prevent excess loading of suspended solids, nutrients, and various pollutants to Stump Pond. The large deposits of sand and silt that have accumulated where the storm drain pipes discharge to this Pond are indicative of poor maintenance of catch basins. These accumulated deposits need to be removed from Stump Pond soon and the partially clogged 30 inch drain pipe may need to be flushed with pressurized water. Since the City's resources for sweeping streets and cleaning catch basins are limited, DEM should investigate the possibility of contracting for these services in a mutual agreement with Gardner to avert these problems in the future. And sites of direct erosion and loading of suspended solids to Dunn Pond, as noted in Appendix XI, should be controlled by DEM as soon as possible. Finally, I encourage DEM to develop a management plan for Dunn Pond and Stump Pond that embraces these recommendations even though that agency has begun to address a few of the problems discussed in this paragraph.

The cooperation of personnel representing federal, state, and city agencies and private consultants was paramount to the successes of this project. This was

particularly true during early stages of planning and design. And the fact that restoration of the Pond and the park were managed by two different state agencies (DEP, then DEQE, and DEM, respectively) is further testimony to the importance of coordination and communication for such a multifaceted project. There was controversy and there were project delays during the construction phase; the stop order issued following the failure of the contractor's sediment trap is an example detailed in this final report. Irrespective of these delays, however, the project was an unequivocal success. One might attribute this to the fact that the problems were well defined and the solutions were reasonable and feasible, but it is also attributable to the effective programs (both federal and state) and guidelines that were coincidently established to facilitate this and other similar projects. The path to success would be more arduous today given the de-emphasis of project-specific funding under Section 314 at the federal level, limited funding at the state level, and given the current permitting climate toward lake restoration projects in Massachusetts.

Dunn Pond now sustains a wide array of recreational and aesthetic activities, and park attendance has increased 230% since it was reopened in 1987. Pond activities include swimming (public beach with lifeguards), boating, fishing and fishing derbies, log rolling and ice skating. Onshore activities include painting, photography, scenic walks, exercise stations, picnicking, programmed events, and just looking and relaxing. The aesthetic pleasures are heightened at Dunn Pond since there are no houses or buildings abutting this body of water or its near shore environs. An exception is the new park building near the public beach on the east side of the Pond, but it is neither obstructive nor offensive. A brief history of this restoration project is presented, with photographs, within the park building for the edification of visitors. Also of historical importance is the large, framed photograph of John Ainsworth Dunn suspended to the left of the main fireplace. The portrait faces Dunn Pond, with a beautiful view to the west cove area. No doubt Mr. Dunn enjoyed this vista in times past, and I believe he would be pleased with that same view today and with the considerable activity at the park he created for the City's public. The conversion of this property to a state park following the combined restoration projects assures that this site will remain a "park and pleasure ground" as envisioned by Mr. Dunn nearly a century ago.

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APPENDIX I

NEWS PHOTOGRAPHS OF 1956 FISHING DERBY

AT DUNN POND

AND

CORRESPONDENCE BY FISH AND GAME BIOLOGISTS

COUNTY SPORTS

BIGGEST STRING AT GARDNER DERBY

GARDNER — One of the biggest strings of fish in the Recreation Department sponsored fishing derby at Dunn Park is displayed by, from left, Thomas O'Mara, 125 Park street, Recreation Director Raymond LaFontaine and Stanley Lawrence of 158 Graham street, who caught the fish.

The derby marked the opening of the pond to general fishing for the season.

FIRST PRIZE WINNER

GARDNER — First prize in the teen-age division of the fishing derby held Saturday afternoon at Dunn Pond was won by Alexander Morze, right, of 13 Crawford street for a 20-inch pickerel. At the left is Gilbert Schaffner of East Gardner admiring the catch with the winner.

Worcester Daily Telegram, July 4, 1955

March 14, 1957

Miss A. T. Coleman, Clerk
City of Gardner
Parks and Playgrounds
Gardner, Mass.

Dear Miss Coleman:

This office has received reports concerning the closure of Dunn Pond, Gardner to ice fishing during the past fishing season. We understand that this was done to prevent accidents inasmuch as the pond in question is used quite heavily for skating. We are sympathetic with the need for the multiple recreational usage of our public waters, but wonder if, during next winter certain sections could not be allotted to each use. This is done in many ponds throughout the Commonwealth.

When we reclaimed and restocked Dunn Pond in 1953 with chain pickerel and yellow perch we did so under an agreement signed January 9, 1945, by Mr. Maio, past chairman, and Mr. Shaw, for the City of Gardner. This agreement stated that Dunn Pond should be kept open for the public to fish in, and that they should be allowed reasonable access thereto. I am certain that the closing of the pond this winter was a result of your sincere concern over the safety of the many children and adults who use it. I should like very much to discuss this matter with your board at their convenience.

Sincerely yours,

William A. Tompkins
Chief Aquatic Biologist

Copy:
Representative Martin H. Walsh
State House, Boston

THE COMMONWEALTH OF MASSACHUSETTS
DIVISION OF FISHERIES AND GAME
Bureau of Wildlife Research and Management

DUNN POND
Gardner, Worcester County

General Information

Dunn Pond is a small artificial pond constructed by the W. P. A. It is now owned by the city of Gardner. It is easily accessible from Route 101. Area: 18 acres. Maximum depth: 5 feet. No boat livery. No trout water.

Stocking History

Largemouth bass (800; 1952) hornpout (2, 120; 1946-50), white perch (2, 375; 1946-50), yellow perch (2, 900; 1946-50) (90 lbs.; 1954), (1, 000; 1955), chain pickerel (174 lbs.; 1954), crappie (750; 1946-47).

Fish and Fishing

Dunn Pond, because of its accessibi lity, is heavily utilized by fishermen. In 1951 fishing was reported as poor by the local warden. Yellow perch and black crappie were small in size and therefore not too desirable to the fishermen. During 1951 the pond was checked by the biological survey crew and found to be over-populated with panfish.

Management

Due to the unbalanced fish population present in Dunn Pond, it was decided to destroy the existing fish population and start over again with a more suitable combination of fishes. The pond was partially drained in September of 1953 and the remaining water areas were treated with rotenone to destroy the fish. Very few game fish were found to be present; the population consisted almost entirely of stunted panfish.

In the Spring of 1954, adult yellow perch and chain pickerel were stocked in the pond. In September, 1954, the pond was checked and young pickerel were found to be abundant. Brown bullheads were also found, indicating that the reclamation had not completely eliminated all of the fish present. There were no signs of the yellow perch stocked in the spring, therefore yellow perch were stocked again the following spring (1955).

In August, 1955, another spot check of the fish population was made. At this time pickerel from 2" to 13" appeared to be abundant, and young yellow perch and bullheads were present in large numbers.

The fish population in Dunn Pond is now in a healthy state. Growth appears to be rapid, and predators (pickerel) appear to be numerous enough to effectively control the panfish population. Legal sized chain pickerel spawned in the pond should start to enter the catch in 1956. Brown bullheads and yellow perch should also provide some fishing this year.

April, 1956.

FORM FG-110. 500-6-56-917886

APPENDIX II

CERTIFICATE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS

ON THE

FINAL ENVIRONMENTAL IMPACT REPORT

AND

COPIES OF PERMITS AND CERTIFICATES

MICHAEL S. DUKAKIS
GOVERNOR

JAMES S. HOYTE
SECRETARY

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

CERTIFICATE OF THE SECRETARY ENVIRONMENTAL AFFAIRS

ON

FINAL ENVIRONMENTAL IMPACT REPORT

PROJECT NAME:	Gardner Urban Heritage State Park
PROJECT LOCATION:	Gardner
EOEA NUMBER:	4070
PROJECT PROPONENT:	City of Gardner
DATE NOTICED IN MONITOR:	February 22, 1983

The Secretary of Environmental Affairs herein issues a statement that the Final Environmental Impact Report submitted in the above referenced project does adequately and properly comply with Massachusetts General Laws, Chapter 30, Section 62-62H inclusive, and the regulations implementing MEPA.

Agencies acting on this project should be aware of the difficulties outlined in the impact reports in maintaining water quality during the construction process, and that both the Draft and Final reports must be reviewed for the entire environmental analysis.

The reports indicate an extreme difficulty in separating the silt from any intermixed water. In fact, the reports indicate coagulants will undoubtedly be necessary if hydraulic dredging is utilized. The use of the Korhonen property for dewatering and ultimate disposal is presented as a challenging, but acceptable site,and as such demands close supervision during the construction process if the described goals of water quality and siltation control are to be fully met.

APR 1991
RECEIVED

Form E
#4070 Gardner

The Central Region DEQE office should be provided a site plan locating all test pits (i.e., 7, 8 and 10) used to determine the limits of the dump to be removed from the banks of Stump Pond and notified of the commencement date prior to the move ment of the dump material to the local SLF.

April 1, 1983
DATE

JAMES S. HOYTE, SECRETARY

Form 4

ORDER OF CONDITIONS
WETLANDS PROTECTION ACT
G.L. CH.131 S.40

CITY/TOWN Gardner FILE NUMBER 160-54

TO: NAME City of Gardner-Dept. of Comm. Dev. & Planning ADDRESS City Hall, Gardner, MA.
John Korhonen 310 Smith St.

CERTIFIED MAIL NUMBER _____

PROJECT LOCATION: Pearl St. & Chapel St.
Address _____

Recorded at Registry of Worcester Book 6674 Page 62

Certificate (if registered) _____

REGARDING:
Notice of Intent dated March 4, 1983

and plans titled and dated _____

THIS ORDER IS ISSUED ON: March 15, 1983

Pursuant to the authority of G.L. CH.131, S.40, the Gardner Conservation Commission has reviewed your Notice of Intent and plans identified above, and has determined that the area on which the proposed work is to be done is significant to one or more of the interests listed in G.L. CH.131 S.40. The Gardner Conservation Commission hereby orders that the following conditions are necessary to protect said interests and all work shall be performed in strict accordance with them and with the Notice of Intent and plans identified above except where such plans are modified by said conditions.

CONDITIONS:

1. Failure to comply with all conditions stated herein, and with all related statutes and other regulatory measures, shall be deemed cause to revoke or modify this order.

2. This order does not grant any property rights or any exclusive privileges; it does not authorize any injury to private property or invasion or private rights.

3. This order does not relieve the permittee or any other person of the necessity of complying with all other applicable federal, state or local statutes ordinances, bylaws and/or regulations.

4. The work authorized hereunder shall be completed within one (1) year from the date of this order unless it is for a maintenance dredging project subject to Section 5(9). This order may be extended by the issuing authority at least thirty (30) days prior to the expiration date of the order or its extension.

6. No work may be commenced until all appeal periods have elapsed from the order of the Conservation Commission or from a final order by the Department of Environmental Quality Engineering.

7. No work shall be undertaken until the final order, with respect to the proposed project, has been recorded in the Registry of Deeds for the district in which the land is located within the chain of title of the affected property. The Document number indicating such recording shall be submitted on the form at the end of this order to the issuer of this order prior to commencement of work.

8. A sign shall be displayed at the site not less than two square feet or more than three square feet bearing the words, "Massachusetts Department of Environmental Quality Engineering Number 160-54 ".

9. Where the Department of Environmental Quality Engineering is requested to make a determination and to issue a superseding order, the Conservation Commission shall be a party to all agency proceedings and hearings before the Department.

10. Upon completion of the work described herein, the applicant shall forthwith request, in writing, that a Certificate of Compliance be issued stating that the work has been satisfactorily completed.

11. The work shall conform to the following described plans and additional conditions.

12. Any instances of siltation at the outlet end of Dunn's Pond will be reported to the Conservation Commission within 48 hours of the occurance in writing and also what corrective action was initiated.

13. Before the Dunn Park project is comlete, a maintenance plan must be submitted to the Conservation Commission for review and approval.

14. Any deviation from the plans submitted shall be reported to the Commission for approval before the change is made.

CONDITIONS CONTINUED FILE NO. 160-54

The applicant, any person aggrieved by this order, any owner of land abutting the land upon which the proposed work is to be done, or any ten residents of the city or town in which land is located, are hereby notified of their right to appeal this order to the Department of Environmental Quality Engineering provided the request is made in writing and by certified mail to the Department within ten (10) days from issuance of this order.

ISSUED BY GARDNER CONSERVATION COMMISSION

Duncan H. Burns Jr.

[signature]

[signature]

[signature]

Theresa H. Hillman

On this 15th day of March 19 83, before me personally appeared Duncan H. Burns, Jr. to me known to be the person described in, and who executed, the foregoing instrument and acknowledged that he executed the same as his free act and deed.

Notary Public [signature] My Commission expires Feb. 27, 19[illegible]

.....

(DETACH ON DOTTED LINE AND SUBMIT TO THE ISSUER OF THIS ORDER PRIOR TO COMMENCEMENT OF

TO _____ (Issuing Authority)

PLEASE BE ADVISED THAT THE ORDER OF CONDITIONS FOR THE PROJECT AT _____

FILE NO. _____, HAS BEEN RECORDED AT THE REGISTRY OF _____

ON _____.
(Date)

If recorded land, the instrument number which identifies this transaction is _____

If registered land, the document number which identifies this transaction is _____

Signed _____
(Applicant)

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs

Department of Environmental Quality Engineering

75 Grove Street
Worcester, MA. 01605

ANTHONY D. CORTESE, Sc. D.
Commissioner

Date: March 10, 1983

Gilbert T. Joly, P.E.
Regional Environmental
Engineer

MAR 11 1983

This Department is in receipt of the following application filed in accordance with the Wetlands Protection Act, General Laws, Chapter 131 Section 40("the Act"):

Name City of Gardner Dept. of Community Development & Planning

City Hall Room 210, Gardner, MA. 01440

Owner of Land John Korhonen 310 Smith St. Gardner, MA. 01440

City/Town Gardner Location Pearl St. & Chapel St.

This project has been given the following Wetlands file number in acco with the Act 160-54 :

The following information is missing and must be forwarded to this off for a complete filing in accordance with the Act:

( ) [redacted] ( ) [redacted] ( ) [redacted]
( ) [redacted]

( ) The plans for the sewage disposal system appear not to meet the requirements of Title 5 of The State Environmental Code for the following reason(s): Review with the Board of Health.

( ) A Chapter 91 License or Permit is not required by the Division of Waterways.

(X) Application has been forwarded to the Division of Waterways to det if a Chapter 91 License or Permit is required. A decision regardi Chapter 91 jurisdiction will be issued by the Division of Waterway no later than _____.

Issuance of a file number indicates only completeness of the file and approval of the application.

For the Commissioner
Gilbert T. Joly PE
Regional Environmental Eng

CC: Conservation Commission
Applicant:
Storch Associates
Waterways

ANTHONY D. CORTESE, Sc. D.
Commissioner

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs
Department of Environmental Quality Engineering
Division of Water Pollution Control
One Winter Street, Boston 02108

June 13, 1983

Mr. David Kinnecom
Storch Associates
2 Charles Gate West
Boston, Massachusetts 02215

Re: Water Quality Certification
Gardner Urban Heritage State Park
Gardner

Dear Mr. Kinnecom:

In response to your request in your petition dated February 15, 1983 submitted to the Division of Water Pollution Control on behalf of the City of Gardner, this Division has reviewed your application for a permit to dredge in Dunn's Pond and construction of a sedimentation basin and storm water drainage alterations to improve water quality in Dunn's Pond. Disposal site for dredge material will be at Korhonen property. Removal of the old dump adjacent to Stump Pond and removal of source of leachate from spoil pile of Pearl Street Relief Sewer with disposal at assigned landfill.

In accordance with the provisions of Section 401 of the Federal Water Pollution Control Act as amended (Public Law 95-217), this Division issues the following Water Quality Certification relative to this project, subject to the following conditions:

1. The dredging portion of the project could result in a violation of water quality standards adopted by this Division. Therefore, reasonable care and diligence shall be taken by the contractor to assure that the proposed activity will be conducted in a manner which will minimize violations of said standards.

2. Sediment control at Dunn's Pond of effluent water will consist of hay bale and stone check dam and silt curtain prior to release to Foster's Brook.

3, Treatment of pumped water from draining of deep excavation areas will occur at outlet of Dunn's Pond by hay bale check dam and silt curtain prior to release.

4. Filter dike to be constructed at south end of Stump Pond to aid in control of water during excavation.

5. Protection of existing wetlands at disposal area, (i.e., hay bale filters, sediment curtain)

6. Korhonen property to be used as the dewatering and disposal site.

Should any violation of the water quality standards or the terms of this certification occur as a result of the proposed activity, the Division will direct that the condition be corrected. Non-compliance on the part of the permittee will be cause for this Division to recommend the revocation of the permit(s) issued therefor or to take such other action as is authorized by the General Laws of the Commonwealth. This certification does not relieve the applicant of the duty to comply with any other statutes or regulations.

Very truly yours,

Thomas C. McMahon

Thomas C. McMahon
Director

TCM/DBS/wp

cc: Anthony D Cortese, Sc.D., Commissioner, Department of Environmental Qualit Engineering, One Winter Street, Boston 02108
Morgan Rees, Chief, Permits Branch, Corps of Engineers, 424 Trapelo Road, Waltham 02154
John J. Hannon, Director, Division of Waterways, Department of Environmenta Quality Engineering, One Winter Street, Boston 02108
Richard Cronin, Director, Division of Fisheries & Wildlife, 100 Cambridge Street, Boston 02202

FEIR - ON SHELF

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
Regulatory Branch, Operations Division
NEDOD-R-23

December 21, 1982

RECEIVED
DEC 23 1982
STORCH ENGINEERS

Mr. David A. Kinnecom
Storch Engineers
2 Charlesgate West
Boston, Massachusetts 02215

Dear Mr. Kinnecom:

This is in regard to your December 6th. visit and your December 7th. letter requesting a determination as to the need for a Department of the Army permit to do some work to upgrade Dunn's Pond in Gardner, Massachusetts. The proposed work includes dredging the pond and placing a filter dike across the Stump Pond outlet to diminish the amount of pollutants into Dunn's Pond. This work is shown on your plans entitled "Gardner Heritage State Park" in 20 sheets, dated "March 1981".

In your meeting with Ms Kathleen Goodrich, and in your letter, you stated that the drainage area of Dunn's Pond was less than 1 square mile and the average annual flow was approximately 2.7 cfs.

This work would be permitted under Title 33 Code of Federal Regulations, Part 330.4(a)(1) as published in the 22 July 1982 Federal Register and does not require submission of an application or further processing.

Prior to construction, you are required to obtain any necessary State and/or local permits.

In addition, care should be taken to dispose of the dredged material in an upland disposal site.

Should you have any questions, you may contact Ms Goodrich at (617) 647-8495.

Sincerely,

Robert J. DeSista
Section Chief
Regulatory Branch
Operations Division

APPENDIX III

COMMENTS ON THE PROPOSED RESTORATION PROJECT

AT DUNN POND

BY

MASSACHUSETTS DIVISION OF FISHERIES AND GAME

AND

U. S. FISH AND WILDLIFE SERVICE

DEQE

The Commonwealth of Massachusetts

Division of Fisheries and Game

Field Headquarters, Westboro 01581

Central Wildlife District
Temple Street; W. Boylston
January 13, 1981

RECEIVED
STORCH ENGINEERS

JAN 14 1981

James L. Fuda
Storch Associates
Two Charlesgate West
Boston, Mass. 02215

Dear Mr. Fuda:

We have some comments to make regarding the proposed project at Dunn's Pond. The presentation on January 7, 1981 by Storch Associates which we attended gave us a better picture of the total impact on fisheries and wildlife related recreation on the area.

As previously noted we will restock Dunn's Pond following completion of construction and refilling. Our intention is to establish a warmwater fish population which will maintain a recreational fishery throughout the year. This population will be augmented by an annual stocking of trout in April. We expect that the trout will provide fishing until late June or early July at which point fishing mortality and excessive warming of the pond will effectively end the trout fishery. We will restock Dunn Pond with the following warmwater species: largemouth bass, chain pickerel, brown bullhead, bluegills and golden shiners. This fish community should be able to maintain a recreational fishery, producing an occasional large bass or pickerel. High fishing pressure will

probably result in a low yield per fisherman.

We are concerned that the dredging of Dunn Pond will result in a bathtub type environment which will lower the productivity of the pond. The maintenence of a portion of the shoreline and cove areas, especially on the eastern side of the pond, in its natural condition will protect some of the cover and structure of the pond. Structure is important to the production of food organisms, as spawning sites, and cover. In addition we would recommend that artificial reefs should be utilized in dredged areas. We have experimented with these constructed of tires in barren ponds with some success.

Concerning the one small island located near the east shore, this has important potential as a wildlife sancutary and nesting site especially for waterfowl. I recommend not to build a bridge to this island as it would be a major attraction and severe change to this small island would result.

Please feel free to contact me at any time for any assistance.

Sincerely,

Chris Thurlow

Chris Thurlow

District Manager

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. Box 1518
Concord, New Hampshire 03301

RECEIVED-EP
FEB 5 1981
WATER QUALITY BRANC
JAN 28 1981

Mike - extra copy

Ms. Marjorie A. Pitts, Chief
Clean Lakes Section
U.S. Environmental Protection Agency
Washington, DC 20460

Dear Ms. Pitts:

We have received your letter, undated, requesting our review of applications for Federal Assistance under the Clean Lakes Program (Sec. 314) for Dunn's Pond and Lake Lashaway, Gardner and North Brookfield, Massachusetts. We have reviewed the material forwarded to us, visited the sites, and discussed the projects with the Massachusetts Division of Fisheries and Wildlife. However, this is not a joint response. We will discuss each lake separately.

Dunn's Pond

Dunn's Pond is a 22-acre man-made lake, enlarged to its present size by construction of an earthen dam in the 1930's. Fish species present include largemouth bass, chain pickerel, pumpkinseed, yellow perch, golden shiner, bullheads and bluegill. No specific information is available on wildlife species, but it can be expected that various species of reptiles and amphibians common to the area would be present, as well as waterfowl. Birds and small mammals would utilize the upland habitat surrounding the pond. The Fish and Wildlife Service's wetland classification system lists Dunn's Pond as palustrine open water. Macrophytic vegetation present in the pond includes yellow waterlilly, water milfoil, bladderwort, pondweed, and burreed.

Lake management problems identified in the application include sedimentation and eutrophication, resulting in gradual establishment of vegetation in the pond. Source of sedimentation is storm water and highway runoff carrying sediments and nutrients into the pond. This has resulted in a reduction of water depths and encouragement of vegetative growth. The recommended plan includes complete dredging of organic sediments within the pond, including removal of vegetation, stumps, and rocks, and diverting storm water and highway runoff into Stump Pond, across Route 101 from Dunn's Pond.

We have concerns with the dredging aspect of the recommended plan. We believe dredging of the coves and inlets and removal of vegetation, stumps and rocks will result in a decrease in fish populations in the pond. Macrophytic vegetation, particularly the burreeds and pondweeds, are valuable wildlife foods and provide cover for young fish and spawning areas for pickerel and yellow perch. Stumps and rocks on the pond bottom also provide cover and "structure"

for fish. Dredging the entire pond will result in a uniform deep-water habitat without the habitat diversity necessary for a range of fish and wildlife species. Increased sediment deposition into Stump Pond will just transfer problems from one pond to another.

Although sedimentation in Dunn's Pond may have been more rapid than usual in the past, it should be recognized that most bodies of water, particularly small lakes and ponds, undergo successional changes over a period of years, gradually moving from open water to emergent wetland to forested wetland, etc., due to sediment buildup. If it is desired to slow successional change, efforts should be directed toward implementing watershed management practices to reduce excessive sediment and nutrient introduction into Drum's Pond and Stump Pond. We would not expect that limited dredging to remove sand and gravel, at the pond inlet next to Route 101 and in the central portion of the pond, would adversely effect fish and wildlife populations. However, the coves and shoreline areas should not be dredged, except at the inlet as mentioned above, and stumps and rocks should be left on the bottom. Thus, we do not favor the recommended plan, and would not recommend dredging coves and shoreline areas under any alternative. However, limited dredging in the central portion of the pond, perhaps 10 feet, would probably not adversely effect fish and wildlife populations, and may be beneficial.

Lake Lashaway

Lake Lashaway is a 293-acre, warmwater lake, heavily utilized for a variety of recreational purposes. A fishery survey by the Massachusetts Division of Fisheries and Wildlife indicated a variety of fish species are found in the lake, including largemouth bass, smallmouth bass, chain pickerel, yellow perch, white perch, black crappie, bluegill, pumpkinseed, and bullheads. Except for weeds, cover is generally poor with few stumps and sparse rocky areas.

The environmental assessment indicates that extensive growth of fanwort (Cabomba caroliniana) is to be managed by installing an outlet pipe to enable an eight (8) foot overwinter drawdown. However, it does not mention what is causing the growth, nor does it define the specific nature of the problem. Land treatment measures and sediment and erosion controls are well implemented in the Lake Lashaway watershed, as noted in the assessment. Indeed, the assessment indicates several adverse impacts could occur as a result of the drawdown. These include dewatering of wetlands upstream along the Fivemile River, and to the west and east of the lake, lowering of water levels in private wells, and erosion and movement of sediments within the lake. A temporary check dam is proposed to maintain ground and surface water levels in wetlands along the Fivemile River. However, the assessment is vague about who will construct and maintain such a dam, and when a more permanent structure would be installed.

We disagree with the assessment's conclusion that a benthic and nearshore environment will persist after drawdown, and that fish populations will improve. There is no information as to how much of the water surface or volume of the lake will remain after an 8-foot drawdown, but it can be predicted that exposed

lake bottom and nearshore areas will freeze, thus annually killing all benthic organisms, many of which are fed on by fish. Removal of the macrophytic vegetation (fanwort and/or other species) will eliminate spawning and nursery habitat for pickerel and yellow perch, and for juveniles of other species as well. We understand the Division of Fisheries and Wildlife would like to establish a northern pike population in the lake. Lack of vegetation would severely hinder or eliminate this possibility. No mention is made of the possible effects on waterfowl or furbearers if vegetation is eliminated.

We do feel the assessment proposes an adequate monitoring program. Again, however, there is lack of assurance that it will be carried out and of what remedial measures would be implemented if adverse effects were noted. Would the drawdown program be halted if adverse effects on wetlands or fish populations were noted? We would recommend that a closer look be given to the need for a drawdown program of the magnitude proposed, and that specific assurances and agreements be worked out regarding lake monitoring, mitigation measures, and remedial action. The alternative of limited weed harvesting should be thoroughly explored.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

APPENDIX IV

POST - CONSTRUCTION GRADING PLAN

OF

DUNN POND

PEARL ST.

BASELINE "A"

BASELINE "C"

THIS SURVEY AND PLAN WERE PREPARED IN ACCORDANCE WITH THE PROCEDURAL AND TECHNICAL STANDARDS FOR THE PRACTICE OF LAND SURVEYING IN THE COMMONWEALTH OF MASS

BY W.D. Pharmer
REG. PROF. LAND SURVEYOR

TOPOGRAPHY BY TRANSIT STADIA METHOD

NOTE - CONTOUR INTERVAL: 2 FT.

DUNN POND

N 72,600E
S 73,400N

N 72,800E
S 73,400N

SEE SHEET 2

0 20 40 80 120 160

GARDNER, MASS.
WORCESTER COUNTY

FINAL GRADING PLAN
DUNN POND

GARDNER HERITAGE STATE PARK

Scale 1" = 40'

Job No. 2008 Sheet No.

County Code

Date MAR. 14, 1985

Drawing No. GAR-L-412312

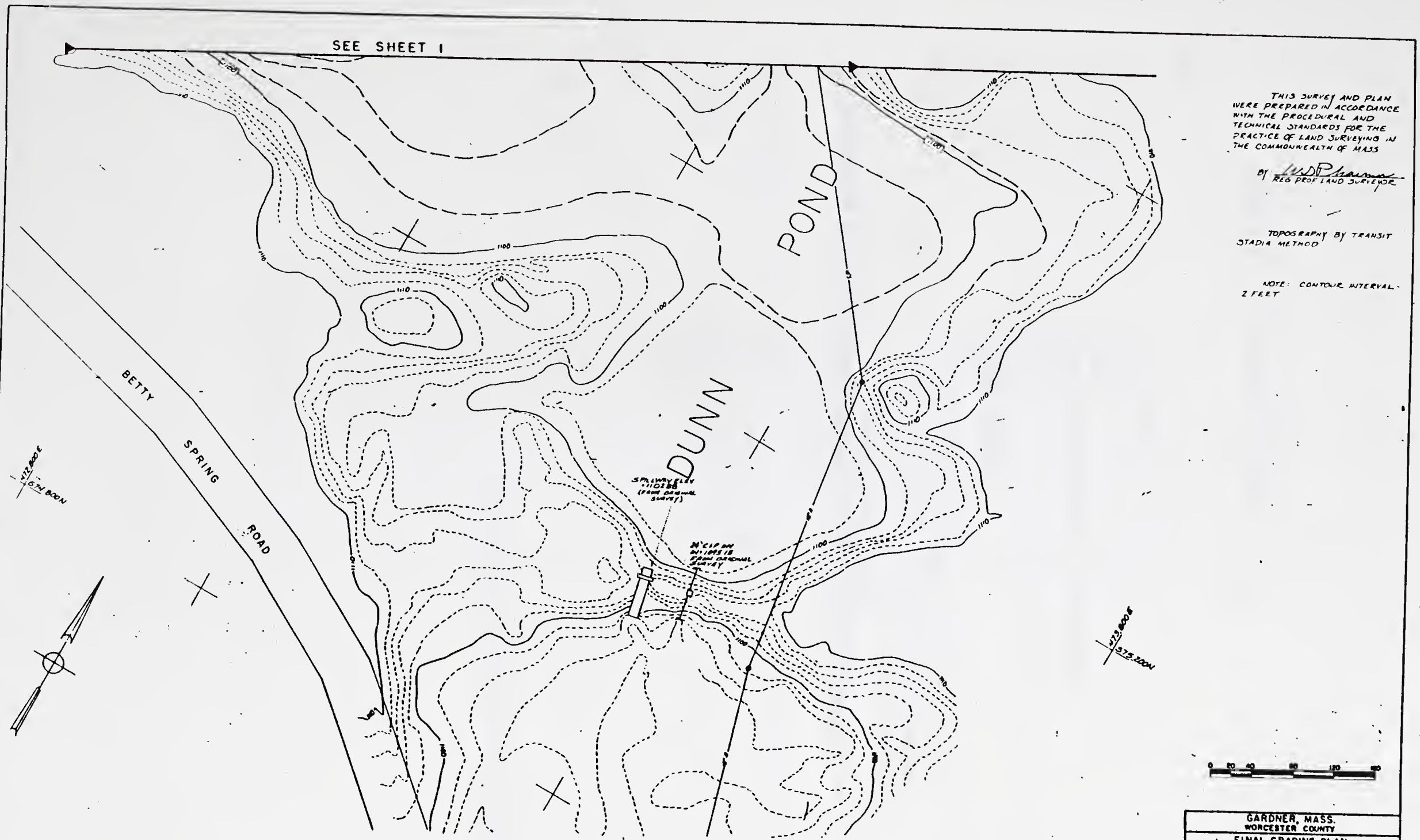
PHARMER ENGINEERING CORPORATION
HOLYOKE MASSACHUSETTS

No.	Description	Date
	REVISIONS	

SHEET 1 OF 2

41

SEE SHEET 1



THIS SURVEY AND PLAN WERE PREPARED IN ACCORDANCE WITH THE PROCEDURAL AND TECHNICAL STANDARDS FOR THE PRACTICE OF LAND SURVEYING IN THE COMMONWEALTH OF MASS

BY W D Pharmer
REG PROF LAND SURVEYOR

TOPOGRAPHY BY TRANSIT STADIA METHOD

NOTE: CONTOUR INTERVAL 2 FEET

GARDNER, MASS.
WORCESTER COUNTY

FINAL GRADING PLAN
DUNN POND

GARDNER HERITAGE STATE PARK

Scale	1" = 40'
Job No.	2006
Comp Code	
Date	MAR 14, 1985
Drawing No.	GAR-L-4123(2)

PHARMER ENGINEERING CORPORATION
HOLYOKE MASSACHUSETTS

No.	Description	Date
	REVISIONS	

SHEET 2 OF 2

APPENDIX V

LOST WORK DAYS DUE TO INCLEMENT WEATHER

SUMMARY OF LOST WORKING DAYS

1984:

Jan. 10, 11, 12,	Snow storm
Jan. 19,	Snow
Jan. 31,	Snow
Feb. 15, thru 22,	Rain; High temps, Flooded Pond
Feb. 24,	Rain
Feb. 28,	Rain
Mar. 14,	Snow
Mar. 29, 30,	Snow
Apr. 4,	Written stop order
Apr. 5, $t_{h_{r_u}}$	Heavy rain thru night caused flooding in Dunn's Pond; still no resolutions for start-up; no other areas available or prepared for start.
Apr. 26,	Letter received from City of Gardner on resolutions.
May 4,	Rain
May 30, 31,	Rain
June 1, thru	Rain - Pond flooded.
June 8,	Rain - Pond flooded.
July 18,	Rain (Heavy)
Dec. 6,	Snow

1985:

Feb. 6,	Snow
Apr. 1,	Snow

Total Lost Working Days = 54 Days

APPENDIX VI

SEVEN YEAR MONITORING PROGRAM DATABASE

Database Units of Measure

Depth = meters

Temp. = °C

pH = units

Spec. Cond. = μmhos/cm

Secchi = meters

Coliform = coliforms/100 ml

All other parameters reported as mg/L

DATABASE FOR THE PHASE II RESTORATION PROJECT OF DUNN POND
IN GARDNER, MASSACHUSETTS

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
17-Jun-82	04	0	14.2	8.2	4.2	--	N.D.	--	0.39	0.10	0.02	0.04	--	N.D.	76	--	--	--
17-Jun-82	05	0	13.4	7.9	4.0	--	1.0	--	0.41	0.10	0.02	0.02	--	21.0	874	--	--	--
17-Jun-82	06	0	13.6	8.7	4.0	--	N.D.	--	0.31	0.10	0.01	0.01	--	1.0	154	--	--	--
17-Jun-82	07	0	15.7	7.4	5.0	--	2.0	--	0.32	0.20	0.02	0.04	--	N.D.	76	--	--	--
17-Jun-82	08	0	15.6	7.9	5.1	--	2.0	--	0.35	0.20	0.02	0.05	--	1.0	64	--	--	--
20-Jul-82	04	0	18.8	5.6	3.9	78	1.0	11.0	1.50	0.30	0.07	0.08	4	2.0	60	--	--	--
20-Jul-82	05	0	18.3	5.8	3.7	92	1.0	8.0	1.20	0.10	0.04	0.13	12	14.0	110	--	--	--
20-Jul-82	06	0	18.9	6.0	3.9	83	N.D.	10.0	0.80	0.10	0.03	0.08	6	1.0	84	--	--	--
20-Jul-82	07	0	21.3	7.2	5.0	86	4.0	10.0	1.40	0.30	0.29	0.15	6	28.0	88	--	--	--
20-Jul-82	08	0	21.0	7.8	5.0	85	5.0	11.0	1.30	0.30	0.28	0.18	8	32.0	100	--	--	--
10-Aug-82	04	0	18.6	6.9	4.1	54	N.D.	9.0	0.70	N.D.	N.D.	0.05	--	N.D.	92	--	--	--
10-Aug-82	05	0	18.5	6.9	4.1	68	N.D.	7.0	0.64	N.D.	N.D.	0.04	4	0.5	88	--	--	--
10-Aug-82	06	0	19.9	8.0	4.1	59	N.D.	9.0	0.58	N.D.	N.D.	0.06	--	6.0	100	--	--	--
10-Aug-82	07	0	22.6	6.2	4.3	60	1.0	9.0	0.60	N.D.	N.D.	0.05	--	2.0	70	--	--	--
10-Aug-82	08	0	22.5	6.4	4.4	59	2.0	10.0	0.67	N.D.	N.D.	0.04	4	2.0	74	--	--	--
27-Oct-82	04	0	4.9	10.1	4.7	39	5.0	15.0	0.66	0.20	0.13	0.06	3	N.D	56	--	--	--
27-Oct-82	05	0	6.9	10.0	4.8	58	1.0	11.0	0.36	N.D.	0.05	0.03	13	N.D	38	--	--	--
27-Oct-82	06	0	7.0	11.5	4.9	50	1.0	15.0	0.56	N.D.	0.07	0.04	8	N.D	52	--	--	--
27-Oct-82	07	0	3.2	10.3	6.8	67	4.0	20.0	0.50	0.10	0.06	0.04	13	N.D	48	--	--	--
27-Oct-82	08	0	3.6	10.4	6.7	67	4.0	19.0	0.40	0.10	0.06	0.03	13	N.D	48	--	--	--
13-Dec-82	06	0	0.1	12.8	4.2	64	10.0	20.0	0.52	0.10	0.06	0.11	8	1.0	70	--	400	<5
13-Dec-82	07	0	0.2	12.4	6.1	74	7.0	25.0	0.97	0.20	0.06	0.15	15	2.0	84	--	480	<5
13-Dec-82	08	0	0.0	11.4	6.0	84	8.0	26.0	1.10	0.20	0.09	0.22	14	2.0	84	--	450	<5
19-Jan-83	06	0	0.0	13.2	5.6	63	5.0	14.0	0.68	0.20	0.04	0.05	6	1.0	58	--	270	<10
19-Jan-83	07	0	-0.3	11.2	5.3	78	7.0	16.0	0.62	0.20	0.04	0.05	11	1.5	70	--	1000	<10
19-Jan-83	08	0	-0.3	11.3	5.3	78	6.0	16.0	0.62	0.20	0.03	0.09	12	1.5	68	--	1100	<10
24-Feb-83	06	0	0.9	12.5	5.2	71	1.0	13.0	0.40	0.20	0.27	0.05	11	1.0	56	--	<10	<10
24-Feb-83	07	0	0.0	12.0	6.7	91	2.0	14.0	0.39	0.60	0.29	0.03	20	1.0	70	--	600	<10
24-Feb-83	08	0	0.0	11.8	6.7	95	2.0	14.0	0.31	0.30	0.27	0.04	19	1.0	70	--	540	<10

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
21-Mar-83	06	0	2.0	12.9	4.2	63	5.0	8.0	0.40	0.10	0.09	0.03	8	0.5	60	--	100	<10
21-Mar-83	07	0	3.6	11.8	5.2	54	3.0	8.0	0.39	0.10	0.06	0.03	9	0.5	50	--	360	20
21-Mar-83	08	0	3.8	11.8	4.7	61	3.0	8.0	0.33	0.10	0.06	0.02	9	0.5	36	--	320	<10
02-Jun-83	04	0	11.8	9.1	4.1	70	2.0	11.0	0.52	1.00	0.32	0.06	5	10.0	60	--	--	--
02-Jun-83	05	0	11.9	7.5	4.0	56	3.0	7.0	0.49	0.10	0.17	0.05	5	12.0	44	--	--	--
02-Jun-83	06	0	13.6	10.4	4.1	69	3.0	10.0	0.95	0.70	0.31	0.06	5	9.0	52	--	--	--
02-Jun-83	07	0	16.0	8.7	4.7	70	5.0	11.0	0.53	0.20	0.09	0.06	9	8.0	52	--	--	--
02-Jun-83	08	0	15.7	8.6	4.7	78	5.0	11.0	0.58	0.10	0.22	0.06	9	10.0	82	--	--	--
16-Jun-83	04	0	15.3	7.9	4.2	68	2.0	10.0	0.63	0.40	0.12	0.10	5	24.0	64	--	--	--
16-Jun-83	05	0	15.7	6.1	4.3	68	1.0	6.0	0.56	0.50	0.15	0.12	10	2.5	64	--	--	--
16-Jun-83	06	0	17.5	9.3	4.2	69	1.0	8.0	0.46	0.10	0.06	0.10	10	N.D.	44	--	--	--
16-Jun-83	07	0	18.0	6.3	4.8	84	7.0	12.0	0.61	0.10	0.08	0.12	5	2.0	56	--	--	--
16-Jun-83	08	0	17.5	5.3	5.1	84	3.0	12.0	0.64	N.D.	0.06	0.11	15	3.0	72	--	--	--
13-Jul-83	06	0	21.0	9.1	4.6	60	2.0	15.0	0.79	0.20	0.15	0.11	10	N.D.	100	--	500	10
13-Jul-83	08	0	20.0	5.6	5.4	71	6.0	69.0	0.96	0.10	0.17	0.14	15	38.0	144	--	200	5
18-Oct-83	06	0	12.7	9.4	4.2	91	2.0	20.0	0.51	0.10	0.02	0.10	8	8.0	58	--	--	--
18-Oct-83	07	0	11.9	9.4	5.1	96	4.0	23.0	0.65	N.D.	0.02	0.10	11	8.0	30	--	--	--
18-Oct-83	08	0	10.3	8.7	5.1	94	3.0	22.0	0.53	0.10	0.03	0.08	10	2.5	8	--	--	--
21-Nov-83	04	0	6.0	10.5	4.3	81	1.0	17.0	0.65	N.D.	0.04	0.03	5	0.5	62	--	160	10
21-Nov-83	05	0	5.6	10.3	4.5	68	1.0	17.0	0.74	N.D.	0.01	0.04	7	N.D.	62	--	40	<10
21-Nov-83	06	0	6.1	11.0	4.5	77	1.0	14.0	0.65	0.10	0.01	0.05	6	0.5	56	--	260	<10
21-Nov-83	07	0	7.8	11.1	5.3	78	2.0	15.0	0.59	0.20	0.09	0.05	9	2.0	66	--	520	10
21-Nov-83	08	0	7.6	10.7	5.3	79	2.0	15.0	0.62	0.10	0.04	0.04	9	2.0	70	--	360	10
05-Jan-84	06	0	0.5	13.5	4.2	96	4.0	16.0	0.35	0.20	0.04	0.04	15	0.5	42	--	40	<5
05-Jan-84	07	0	0.2	12.1	5.0	130	11.0	17.0	0.56	0.20	0.10	0.05	26	9.5	64	--	40	<5
05-Jan-84	08	0	0.0	12.0	4.9	132	8.0	17.0	0.31	0.20	0.05	0.05	28	7.0	52	--	20	<5
08-Mar-84	06	0	0.5	14.4	4.1	91	11.0	20.0	0.52	0.10	0.01	0.12	15	0.5	48	--	10	<5
08-Mar-84	07	0	2.8	13.1	4.9	177	2.0	14.0	0.80	0.20	0.01	0.11	40	1.0	116	--	20	<5
08-Mar-84	08	0	1.9	13.0	5.0	181	2.0	19.0	0.68	0.20	0.01	0.05	43	0.5	136	--	5	<5
28-Mar-84	06	0	1.8	14.2	4.0	82	5.0	11.0	0.49	0.10	0.48	0.05	12	5.0	8	--	--	--
28-Mar-84	07	0	3.5	13.6	4.8	87	3.0	13.0	0.33	0.10	0.32	0.07	15	18.0	20	--	--	--
28-Mar-84	08	0	3.3	12.7	4.9	88	4.0	14.0	0.36	0.10	0.31	0.06	15	14.0	18	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
30-Apr-84	06	0	12.0	12.6	4.2	78	4.0	13.0	0.74	0.20	0.33	0.11	9	0.5	58	--	20	20
30-Apr-84	07	0	15.4	10.2	4.8	106	3.0	13.0	0.82	0.10	0.02	0.06	18	12.0	88	--	<20	10
30-Apr-84	08	0	14.9	10.2	4.7	102	3.0	13.0	0.51	0.30	0.01	0.04	17	2.5	76	--	<20	<10
30-Apr-84	09	0	9.8	10.9	4.3	66	2.0	8.0	0.50	0.10	0.01	0.07	8	0.5	48	--	<20	<10
30-Apr-84	10	0	11.7	11.0	4.8	99	2.0	12.0	0.77	0.10	N.D.	0.04	16	1.5	68	--	<20	<10
30-Apr-84	11	0	11.3	10.8	4.8	32	2.0	11.0	0.61	0.50	0.07	0.03	14	2.0	56	--	<20	<10
10-May-84	06	0	9.1	10.5	3.9	67	1.0	9.0	0.89	0.10	0.09	0.09	8	N.D.	18	--	240	<10
10-May-84	07	0	9.6	9.7	5.2	90	1.0	13.0	0.75	0.10	0.05	0.25	14	3.5	22	--	220	<10
10-May-84	08	0	9.4	9.0	5.1	87	N.D.	12.0	0.66	0.10	0.04	0.05	14	1.5	18	--	200	<10
10-May-84	09	0	8.1	10.4	4.0	58	N.D.	8.0	0.38	0.10	0.04	0.04	7	0.5	8	--	40	<10
10-May-84	10	0	8.5	10.5	4.8	84	2.0	12.0	0.47	0.10	0.04	0.03	14	3.0	20	--	60	<10
10-May-84	11	0	9.6	9.3	4.5	73	2.0	12.0	0.50	N.D.	0.04	0.04	11	1.5	10	--	100	<10
26-Jun-84	06	0	15.9	9.5	3.9	69	5.0	11.0	0.41	0.10	0.18	0.04	8	2.0	88	--	--	--
26-Jun-84	07	0	20.2	9.7	4.8	101	4.0	18.0	0.19	0.10	0.04	0.05	12	5.5	118	--	--	--
26-Jun-84	08	0	18.3	9.1	4.8	100	4.0	19.0	0.23	0.10	0.19	0.06	14	4.5	114	--	--	--
26-Jun-84	09	0	16.6	9.3	4.7	98	3.0	18.0	0.74	0.10	0.05	0.06	14	15.0	120	--	--	--
26-Jun-84	10	0	13.7	9.6	3.9	70	2.0	19.0	0.49	N.D.	0.01	0.03	10	0.5	86	--	--	--
26-Jun-84	11	0	17.9	8.7	4.5	97	4.0	16.0	0.55	N.D.	0.01	0.07	14	1.5	116	--	--	--
12-Jul-84	06	0	18.7	8.6	4.0	66	2.0	10.0	0.68	0.10	0.03	0.05	7	4.0	74	--	400	80
12-Jul-84	07	0	20.7	8.7	4.9	104	3.0	18.0	0.89	0.10	0.01	0.09	11	20.0	102	--	160	50
12-Jul-84	08	0	19.2	7.7	5.0	103	4.0	19.0	1.30	0.20	0.03	0.10	11	16.0	102	--	420	40
12-Jul-84	09	0	17.7	8.9	4.7	99	3.0	16.0	0.64	0.10	0.01	0.06	9	5.5	82	--	240	40
12-Jul-84	10	0	15.4	9.1	4.0	62	1.0	8.0	0.67	N.D.	0.05	0.04	8	2.0	48	--	60	<5
12-Jul-84	11	0	19.5	8.3	4.5	89	2.0	15.0	0.65	0.50	0.22	0.06	10	7.5	72	--	20	<5
01-Aug-84	06	0	22.6	7.8	4.5	77	1.0	13.0	0.40	0.60	0.11	0.04	10	3.5	78	--	--	--
01-Aug-84	07	0	21.2	6.8	6.2	138	4.0	30.0	0.26	0.20	0.07	0.05	15	9.0	114	--	--	--
01-Aug-84	08	0	22.9	8.6	6.1	142	4.0	28.0	0.82	N.D.	0.05	0.06	16	5.5	106	--	--	--
01-Aug-84	09	0	19.7	7.6	5.4	125	3.0	25.0	0.60	0.30	0.12	0.03	15	2.0	90	--	--	--
01-Aug-84	10	0	15.6	7.8	4.3	59	3.0	9.0	0.46	0.30	0.10	0.04	7	5.5	46	--	--	--
01-Aug-84	11	0	21.3	8.9	6.1	94	2.0	17.0	0.81	0.10	0.04	0.05	12	3.0	74	--	--	--
13-Aug-84	06	0	20.3	8.3	4.3	85	2.0	13.0	1.40	0.20	0.02	0.07	11	4.0	110	--	--	--
13-Aug-84	07	0	22.7	7.2	5.0	165	4.0	32.0	0.95	N.D.	N.D.	0.06	16	11.0	180	--	--	--
13-Aug-84	08	0	21.5	6.6	5.2	158	4.0	30.0	1.30	N.D.	0.02	0.05	16	5.0	140	--	--	--
13-Aug-84	09	0	20.4	7.4	4.6	146	2.0	27.0	0.60	0.10	0.01	0.04	16	2.5	130	--	--	--
13-Aug-84	10	0	17.2	8.7	4.3	58	1.0	8.0	0.64	N.D.	N.D.	0.04	7	2.0	66	--	--	--
13-Aug-84	11	0	22.2	7.7	5.0	110	2.0	22.0	0.70	N.D.	0.01	0.04	14	3.0	110	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
23-Aug-84	06	0	17.5	7.7	5.1	83	2.0	14.0	0.58	0.20	N.D.	0.14	12	4.0	104	--	--	--
23-Aug-84	07	0	19.8	6.1	5.1	168	3.0	33.0	0.45	N.D.	0.02	0.10	17	25.0	160	--	--	--
23-Aug-84	08	0	19.0	6.5	5.4	160	1.0	33.0	0.44	N.D.	0.03	0.07	17	5.0	148	--	--	--
23-Aug-84	09	0	18.0	7.7	5.3	155	1.0	33.0	0.46	0.10	0.02	0.07	17	4.0	140	--	--	--
23-Aug-84	10	0	15.5	8.1	4.7	63	1.0	8.0	0.20	N.D.	0.02	0.06	8	2.5	64	--	--	--
23-Aug-84	11	0	19.6	8.7	6.3	112	2.0	20.0	0.51	N.D.	0.01	0.08	14	4.5	114	--	--	--
10-Sep-84	06	0	18.1	8.5	5.2	97	4.0	16.0	1.00	0.10	0.06	0.09	14	0.5	46	--	400	<5
10-Sep-84	07	0	18.3	6.8	5.3	163	6.0	26.0	1.00	N.D.	0.12	0.09	19	7.0	48	--	180	<5
10-Sep-84	08	0	16.2	6.9	5.4	154	7.0	25.0	0.91	0.10	0.12	0.08	18	2.0	36	--	80	<5
10-Sep-84	09	0	14.5	7.1	4.7	149	3.0	22.0	0.91	0.20	0.02	0.07	18	N.D.	10	--	20	<5
10-Sep-84	11	0	16.5	8.2	5.0	111	3.0	17.0	1.10	N.D.	0.01	0.09	14	1.0	36	--	<5	<5
24-Sep-84	07	0	19.9	7.5	6.1	181	8.0	34.0	0.70	0.40	0.17	0.12	19	19.0	150	--	80	10
24-Sep-84	08	0	17.9	6.7	5.9	153	5.0	37.0	0.59	0.20	0.13	0.09	19	6.5	130	--	40	<5
24-Sep-84	09	0	15.4	7.1	6.1	158	4.0	28.0	0.62	0.40	0.08	0.07	18	5.0	130	--	40	<5
24-Sep-84	11	0	18.5	8.7	5.8	113	2.0	18.0	0.49	N.D.	0.05	0.08	16	5.5	92	--	5	<5
15-Oct-84	07	0	11.6	11.3	5.5	299	4.0	60.0	0.95	N.D.	0.12	0.07	19	6.5	178	--	250	<5
15-Oct-84	08	0	9.9	8.3	4.6	281	3.0	54.0	0.91	N.D.	0.14	0.06	17	2.5	166	--	100	<5
15-Oct-84	09	0	10.1	8.5	4.6	261	3.0	53.0	0.50	N.D.	0.04	0.06	17	1.5	140	--	110	<5
15-Oct-84	10	0	9.3	11.4	5.4	75	3.0	10.0	0.66	N.D.	0.02	0.07	7	3.5	58	--	350	<5
15-Oct-84	11	0	11.1	12.3	5.5	176	2.0	33.0	0.63	N.D.	N.D.	0.08	12	2.5	108	--	160	<5
29-Oct-84	04	0	12.3	7.8	4.1	88	3.0	13.0	0.75	N.D.	N.D.	0.04	6	6.0	96	--	--	--
29-Oct-84	05	0	11.4	8.6	3.8	106	1.0	9.0	0.81	N.D.	0.01	0.03	16	4.0	80	--	--	--
29-Oct-84	06	0	13.2	7.8	4.2	92	1.0	13.0	0.88	0.10	N.D.	0.04	10	6.0	84	--	--	--
29-Oct-84	07	0	15.0	7.2	4.0	220	N.D.	42.0	0.67	N.D.	0.03	0.05	12	16.0	160	--	--	--
29-Oct-84	08	0	14.6	7.2	4.0	215	N.D.	40.0	0.55	0.10	0.03	0.05	12	7.5	180	--	--	--
29-Oct-84	09	0	13.7	8.1	4.1	198	1.0	41.0	0.99	N.D.	N.D.	0.04	12	1.5	150	--	--	--
29-Oct-84	10	0	12.5	9.1	4.3	73	2.0	10.0	0.51	N.D.	N.D>	0.04	8	3.0	76	--	--	--
29-Oct-84	11	0	14.3	8.5	4.4	147	1.0	28.0	0.71	0.60	0.10	0.04	11	6.7	130	--	--	--
28-Nov-84	04	0	2.9	12.2	4.4	80	1.0	15.0	1.60	0.10	0.85	0.14	8	4.5	86	--	160	<5
28-Nov-84	05	0	4.2	12.0	4.2	79	N.D.	8.0	1.30	0.10	0.94	0.11	12	3.5	98	--	40	<5
28-Nov-84	06	0	4.3	12.1	5.2	92	4.0	15.0	0.97	0.10	0.88	0.10	13	3.5	78	--	320	10
28-Nov-84	07	0	3.0	11.2	4.0	257	N.D.	52.0	1.10	0.20	1.00	0.10	14	6.5	170	--	100	<10
28-Nov-84	08	0	3.4	11.6	4.0	251	N.D.	52.0	1.20	0.10	0.89	0.10	14	5.5	180	--	120	<10
28-Nov-84	09	0	3.4	12.8	4.7	62	N.D.	49.0	0.95	0.10	0.92	0.09	13	3.0	160	--	40	<10
28-Nov-84	10	0	3.0	12.2	4.2	237	2.0	10.0	1.40	N.D.	0.91	0.11	8	1.0	52	--	180	<10
28-Nov-84	11	0	4.2	11.7	4.2	185	1.0	38.0	0.95	0.10	0.88	0.08	13	3.0	110	--	160	5

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
13-Dec-84	04	0	2.7	12.1	4.0	95	2.0	14.0	0.82	0.10	0.01	0.10	10	2.5	50	--	--	--
13-Dec-84	05	0	3.2	11.6	3.7	87	N.D.	9.0	0.87	0.10	N.D.	0.08	10	5.0	40	--	--	--
13-Dec-84	06	0	3.6	12.2	4.9	111	3.0	17.0	0.87	0.10	0.04	0.08	18	4.0	72	--	--	--
13-Dec-84	07	0	2.4	11.1	4.3	198	N.D.	44.0	0.83	0.10	0.01	0.08	17	9.0	120	--	--	--
13-Dec-84	08	0	2.3	11.3	3.9	202	N.D.	42.0	0.92	0.10	0.02	0.08	17	8.5	94	--	--	--
13-Dec-84	09	0	2.2	12.6	3.7	70	N.D.	47.0	0.84	0.10	0.01	0.08	18	4.5	100	--	--	--
13-Dec-84	10	0	3.1	12.7	4.3	210	2.0	12.0	0.63	N.D.	N.D.	0.08	9	3.5	28	--	--	--
13-Dec-84	11	0	2.2	12.3	3.9	212	N.D.	35.0	0.69	0.20	0.02	0.06	18	4.0	82	--	--	--
13-Mar-85	04	0	0.5	12.3	2.7	89	N.D.	12.0	0.35	0.10	0.08	0.06	12	3.5	100	--	40	<5
13-Mar-85	05	0	0.7	10.9	4.5	67	2.0	9.0	0.27	0.20	0.04	0.05	8	3.5	86	--	5	<5
13-Mar-85	06	0	0.8	12.9	3.9	100	3.0	12.0	0.38	0.20	0.03	0.06	14	4.5	100	--	20	<5
13-Mar-85	07	0	2.6	10.2	3.6	194	1.0	29.0	0.50	0.20	0.04	0.06	28	9.5	150	--	10	<5
13-Mar-85	08	0	2.7	12.7	3.5	128	3.0	18.0	0.23	0.10	0.03	0.04	24	3.0	120	--	80	<5
10-Apr-85	02	0	7.1	10.8	4.0	220	--	--	--	--	--	--	--	--	--	--	--	--
10-Apr-85	03	0	6.5	10.8	4.9	160	--	--	--	--	--	--	--	--	--	--	--	--
10-Apr-85	06	0	6.5	10.7	4.3	220	--	--	--	--	--	--	--	--	--	--	--	--
10-Apr-85	07	0	6.5	10.8	3.9	220	--	--	--	--	--	--	--	--	--	--	--	--
10-Apr-85	08	0	6.5	10.6	4.0	220	--	--	--	--	--	--	--	--	--	--	--	--
23-Apr-85	01	0	13.7	10.4	3.8	213	2.0	27.0	0.34	0.20	0.03	0.14	36	5.5	110	1.8	<10	<5
23-Apr-85	01	6	6.4	5.2	3.3	444	N.D.	31.0	0.30	0.20	0.01	0.07	37	12.0	140	--	--	--
23-Apr-85	02	0	13.5	10.2	3.8	214	1.0	27.0	0.30	0.20	0.01	0.03	36	5.5	100	--	80	<5
23-Apr-85	03	0	12.1	9.4	3.9	126	1.0	16.0	0.32	0.10	0.01	0.02	23	6.0	76	--	60	<5
23-Apr-85	04	0	8.1	12.3	3.5	112	N.D.	15.0	0.31	0.10	0.01	0.03	17	4.0	68	--	40	<5
23-Apr-85	05	0	7.5	12.0	3.3	87	N.D.	8.0	0.31	0.10	0.01	0.02	12	4.0	50	--	400	<5
23-Apr-85	06	0	11.2	9.6	4.7	143	2.0	20.0	0.38	0.20	0.01	0.03	27	5.0	80	--	40	<5
23-Apr-85	07	0	13.3	10.3	3.9	214	1.0	27.0	0.35	0.20	0.01	0.02	36	7.0	120	--	-5	<5
23-Apr-85	08	0	12.6	9.3	3.8	212	N.D.	27.0	0.51	0.20	0.02	0.08	37	5.5	100	--	10	<5
07-May-85	01	0	12.9	9.2	3.8	208	3.0	23.0	0.96	0.10	0.07	0.07	35	7.5	64	2.0	40	<10
07-May-85	01	7	6.6	N.D.	3.6	868	N.D.	87.0	0.97	N.D.	0.07	0.07	29	17.0	550	--	--	--
07-May-85	02	0	12.1	9.0	3.9	209	2.0	23.0	0.78	0.10	0.01	0.06	36	7.5	80	--	40	<10
07-May-85	03	0	10.1	8.8	4.4	119	1.0	13.0	0.87	0.10	0.01	0.07	22	8.0	34	--	300	<10
07-May-85	04	0	7.8	10.0	3.6	100	N.D.	12.0	0.65	0 10	0.01	0.08	14	5.0	28	--	200	<10
07-May-85	05	0	8.0	9.0	3.6	85	N.D.	7.0	0.75	0..	N.D.	0.09	13	5.0	20	--	120	<10
07-May-85	06	0	10.2	8.7	5.2	125	2.0	16.0	0.84	0.10	N.D.	0.09	23	7.0	36	--	80	<10
07-May-85	07	0	11.8	8.9	3.9	208	1.0	24.0	0.60	0.10	0.01	0.09	36	5.0	72	--	220	<10
07-May-85	08	0	11.8	8.5	3.9	208	N.D.	26.0	0.72	0.10	0.01	0.03	36	5.0	78	--	160	<10

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
23-May-85	01	0	19.0	9.2	3.9	201	1.0	26.0	0.71	N.D.	0.01	0.02	33	3.5	130	2.6	--	--
23-May-85	02	0	19.2	8.9	3.8	201	1.0	26.0	0.48	N.D.	0.01	0.01	34	2.0	130	--	--	--
23-May-85	03	0	16.3	8.2	3.9	101	2.0	13.0	1.10	N.D.	0.01	0.05	16	5.0	94	--	--	--
23-May-85	04	0	11.6	9.8	3.4	98	N.D.	13.0	0.81	0.10	0.01	0.03	12	1.0	88	--	--	--
23-May-85	05	0	11.8	9.2	3.4	84	N.D.	7.0	0.86	0.10	0.01	0.04	12	0.5	66	--	--	--
23-May-85	06	0	17.6	8.3	4.1	176	1.0	25.0	0.70	0.10	0.01	0.03	30	2.5	130	--	--	--
23-May-85	07	0	18.7	8.9	4.0	201	1.0	23.0	0.74	0.10	0.05	0.04	33	2.0	120	--	--	--
23-May-85	08	0	18.2	8.5	3.9	199	1.0	24.0	0.78	0.10	0.02	0.01	33	2.5	110	--	--	--
03-Jun-85	01	0	20.7	9.4	4.4	188	3.0	26.0	0.70	N.D.	N.D.	0.04	33	N.D.	100	3.0	--	--
03-Jun-85	01	7	7.1	N.D.	4.0	810	N.D.	99.0	0.83	N.D.	N.D.	0.04	26	N.D.	624	--	--	--
03-Jun-85	02	0	20.7	8.1	4.4	190	2.0	26.0	0.86	N.D.	0.01	0.04	32	1.0	106	--	--	--
03-Jun-85	03	0	20.4	7.7	4.9	90	2.0	14.0	0.77	0.10	N.D.	0.08	16	N.D.	72	--	--	--
03-Jun-85	04	0	13.8	8.3	3.6	103	N.D.	14.0	0.83	0.10	N.D.	0.06	15	1.5	70	--	--	--
03-Jun-85	05	0	12.8	8.9	3.7	67	N.D.	7.0	1.20	0.10	N.D.	0.10	11	1.0	56	--	--	--
03-Jun-85	06	0	20.1	7.2	5.3	179	1.0	27.0	0.73	N.D.	N.D.	0.03	31	1.5	96	--	--	--
03-Jun-85	07	0	20.4	7.4	4.3	189	N.D.	25.0	1.10	N.D.	N.D.	0.04	32	5.0	104	--	--	--
03-Jun-85	08	0	19.7	7.1	4.6	187	1.0	24.0	0.68	N.D.	N.D.	0.03	32	0.5	98	--	--	--
19-Jun-85	01	0	19.6	8.4	--	184	2.0	19.0	0.63	0.10	0.43	0.04	32	N.D.	106	5.8	--	--
19-Jun-85	01	7	7.2	N.D.	--	820	N.D.	85.0	0.76	0.10	0.43	0.04	--	1.0	562	--	--	--
19-Jun-85	02	0	19.2	8.5	4.5	184	2.0	19.0	0.27	0.20	0.16	0.03	32	0.5	116	--	--	--
19-Jun-85	03	0	19.0	8.7	5.2	98	4.0	12.0	0.51	0.30	0.10	0.04	22	3.0	84	--	--	--
19-Jun-85	04	0	12.8	8.3	3.8	91	N.D.	10.0	0.44	0.10	N.D.	0.05	30	7.5	62	--	--	--
19-Jun-85	05	0	12.6	8.9	4.1	64	N.D.	6.0	0.58	N.D.	0.01	0.04	14	12.0	88	--	--	--
19-Jun-85	06	0	19.3	7.2	5.3	171	3.0	23.0	0.56	N.D.	0.01	0.03	30	0.5	112	--	--	--
19-Jun-85	07	0	19.0	8.3	4.5	182	3.0	23.0	0.30	N.D.	0.05	0.02	32	N.D.	114	--	--	--
19-Jun-85	08	0	18.0	7.5	4.6	178	2.0	19.0	0.32	N.D.	0.03	0.02	31	N.D.	114	--	--	--
02-Jul-85	01	0	20.9	8.2	4.0	220	2.0	22.0	0.27	N.D.	0.06	0.03	32	N.D.	110	4.6	--	--
02-Jul-85	01	7	7.5	N.D.	2.8	972	N.D.	84.0	0.56	--	0.21	0.05	--	5.5	800	--	--	--
02-Jul-85	02	0	20.8	8.0	4.4	221	1.0	22.0	0.33	N.D.	0.02	0.03	32	1.0	110	--	--	--
02-Jul-85	03	0	20.5	7.8	4.8	112	1.0	13.0	0.51	0.60	0.33	0.07	21	1.5	100	--	--	--
02-Jul-85	04	0	13.6	8.4	3.4	125	N.D.	12.0	0.55	0.10	0.02	0.10	16	36.0	88	--	--	--
02-Jul-85	05	0	12.9	7.8	3.8	87	1.0	6.0	0.42	0.20	0.17	0.08	12	1.0	80	--	--	--
02-Jul-85	06	0	20.7	7.8	5.0	188	3.0	20.0	0.56	0.10	0.05	0.04	17	1.5	100	--	--	--
02-Jul-85	07	0	20.3	8.2	4.6	219	1.0	22.0	0.35	N.D.	0.03	0.04	30	2.0	120	--	--	--
02-Jul-85	08	0	19.2	7.2	4.4	214	2.0	21.0	0.47	0.20	0.10	0.04	30	1.0	120	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
15-Jul-85	01	0	23.6	7.6	4.2	221	1.0	24.0	0.95	0.50	0.07	0.03	31	N.D.	120	3.4	20	10
15-Jul-85	01	7	8.5	0.3	--	965	N.D.	58.0	1.10	0.20	0.22	0.02	34	4.5	310	--	--	--
15-Jul-85	02	0	24.1	7.1	4.9	222	1.0	25.0	1.10	0.10	0.16	0.01	31	2.0	120	--	140	40
15-Jul-85	03	0	21.9	4.9	5.8	144	4.0	16.0	1.30	0.20	0.20	0.07	20	6.5	98	--	850	320
15-Jul-85	06	0	21.6	6.2	5.7	148	3.0	17.0	1.20	0.40	0.48	0.07	20	5.5	110	--	1400	500
15-Jul-85	07	0	23.7	8.1	4.9	221	1.0	22.0	1.10	N.D.	0.21	0.02	31	2.5	130	--	100	20
15-Jul-85	08	0	22.9	7.4	4.9	219	1.0	22.0	1.00	0.20	0.20	0.02	31	3.5	120	--	240	20
30-Jul-85	01	0	24.7	8.3	4.9	189	4.0	21.0	0.88	0.20	0.08	0.06	31	N.D.	100	4.4	--	--
30-Jul-85	01	7	8.8	4.2	5.2	855	N.D.	79.0	0.96	--	0.22	0.02	--	6.0	560	--	--	--
30-Jul-85	02	0	24.3	8.2	4.8	188	2.0	22.0	0.86	N.D.	0.11	0.03	31	N.D.	90	--	--	--
30-Jul-85	03	0	23.1	7.8	5.2	92	3.0	11.0	1.40	.70	0.06	0.07	13	N.D.	84	--	--	--
30-Jul-85	06	0	24.3	7.8	5.1	186	2.0	21.0	1.20	N.D.	0.04	0.04	33	2.0	94	--	--	--
30-Jul-85	07	0	23.9	7.9	4.7	187	N.D.	23.0	1.00	0.60	0.09	0.12	31	2.0	120	--	--	--
30-Jul-85	08	0	22.8	7.4	4.9	156	2.0	22.0	0.94	0.60	0.13	0.05	30	N.D.	88	--	--	--
13-Aug-85	01	0	24.4	7.5	4.8	176	1.0	21.0	1.10	0.10	0.04	0.08	30	2.0	80	3.2	--	--
13-Aug-85	01	7	9.0	1.4	3.6	885	N.D.	75.0	1.30	--	0.21	0.05	--	2.5	458	--	--	--
13-Aug-85	02	0	24.8	7.3	4.9	181	1.0	21.0	0.48	N.D.	0.03	0.04	29	1.0	1980	--	--	--
13-Aug-85	03	0	22.6	7.8	6.5	153	3.0	12.0	0.80	N.D.	0.04	0.08	24	0.5	72	--	--	--
13-Aug-85	06	0	23.7	5.7	5.5	173	2.0	23.0	0.40	N.D.	0.02	0.04	30	1.5	78	--	--	--
13-Aug-85	07	0	23.3	7.4	4.7	177	1.0	22.0	0.38	N.D.	0.01	0.08	30	1.0	78	--	--	--
13-Aug-85	08	0	20.3	7.0	5.5	145	2.0	21.0	0.43	N.D.	0.07	0.05	29	7.0	82	--	--	--
04-Sep-85	01	0	19.8	8.1	4.6	146	N.D.	23.0	0.92	N.D.	0.01	0.03	28	4.0	110	3.0	--	--
04-Sep-85	01	7	--	--	--	--	N.D.	89.0	1.60	--	0.33	0.08	--	63.0	830	--	--	--
04-Sep-85	01	7	9.8	1.7	4.8	720	--	--	--	--	--	--	--	--	--	--	--	--
04-Sep-85	02	0	19.9	8.7	4.6	170	N.D.	22.0	0.87	N.D.	0.02	0.03	27	35.0	120	--	--	--
04-Sep-85	03	0	18.9	8.6	5.4	110	2.0	15.0	1.00	0.10	0.03	0.04	23	6.0	110	--	--	--
04-Sep-85	06	0	19.3	7.0	6.4	168	N.D.	24.0	0.87	N.D.	N.D.	0.05	27	3.5	120	--	--	--
04-Sep-85	07	0	19.7	8.4	4.5	168	N.D.	21.0	0.96	N.D.	0.01	0.05	26	6.5	120	--	--	--
04-Sep-85	08	0	19.3	7.8	4.7	163	N.D.	21.0	1.00	N.D.	0.02	0.06	27	5.5	130	--	--	--
23-Sep-85	01	0	18.6	9.0	4.6	172	3.0	21.0	0.79	N.D.	0.01	0.02	28	4.0	120	4.2	--	--
23-Sep-85	01	7	9.4	1.7	3.5	871	4.0	84.0	1.00	--	0.46	0.03	--	10.0	690	--	--	--
23-Sep-85	02	0	18.9	8.8	4.5	171	N.D.	21.0	0.76	0.10	0.04	0.02	28	6.5	160	--	--	--
23-Sep-85	03	0	17.0	9.6	6.0	133	1.0	17.0	0.81	0.30	0.03	0.09	30	5.5	140	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
21-Oct-85	01	0	12.1	8.0	3.3	165	N.D.	20.0	0.32	N.D.	0.04	0.03	25	5.5	94	1.6	--	--
21-Oct-85	01	7	9.5	N.D.	4.3	892	3.0	93.0	0.68	-	0.43	0.03	--	10.0	610	--	--	--
21-Oct-85	02	0	11.6	8.5	3.2	164	N.D.	19.0	0.44	N.D.	0.03	0.03	25	5.5	100	--	--	--
21-Oct-85	03	0	9.8	6.9	3.9	108	1.0	13.0	0.41	0.30	0.10	0.03	22	5.0	100	--	--	--
21-Oct-85	04	0	7.0	9.1	2.2	102	N.D.	11.0	0.39	0.10	0.02	0.04	18	5.5	86	--	--	--
21-Oct-85	05	0	9.1	8.5	2.9	65	N.D.	6.0	0.34	N.D.	0.03	0.04	11	4.0	110	--	--	--
21-Oct-85	06	0	10.6	6.9	4.2	134	3.0	18.0	0.42	N.D.	0.03	0.03	24	6.0	120	--	--	--
21-Oct-85	07	0	10.7	9.5	2.9	160	N.D.	19.0	0.43	N.D.	0.02	0.03	25	6.5	110	--	--	--
21-Oct-85	08	0	10.1	8.7	2.8	155	N.D.	20.0	0.54	N.D.	0.03	0.02	25	5.0	130	--	--	--
10-Dec-85	03	0	1.3	12.2	--	100	N.D.	13.0	1.10	0.20	0.02	0.06	20	6.5	110	--	260	<10
10-Dec-85	04	0	0.5	12.7	--	102	N.D.	12.0	1.00	0.20	0.05	0.06	17	7.0	76	--	200	<10
10-Dec-85	05	0	1.4	11.4	--	73	N.D.	7.0	0.79	0.10	0.03	0.06	13	8.5	60	--	20	<10
10-Dec-85	06	0	1.8	10.9	--	143	3.0	15.0	1.10	0.20	0.05	0.06	32	3.5	110	--	280	<10
10-Dec-85	07	0	1.6	12.1	--	173	N.D.	19.0	1.20	0.10	0.04	0.06	37	8.0	130	--	10	<10
10-Dec-85	08	0	1.3	12.2	--	170	N.D.	19.0	1.10	0.10	0.04	0.06	30	7.0	110	--	20	<10
28-Jan-86	03	0	-0.3	12.9	5.4	73	N.D.	5.0	1.10	0.10	0.03	0.07	12	9.0	120	--	40	<5
28-Jan-86	06	0	0.0	12.7	4.6	79	N.D.	8.0	1.00	0.20	0.05	0.06	13	4.5	94	--	50	<5
28-Jan-86	07	0	1.6	12.4	4.6	156	2.0	14.0	0.99	0.20	0.07	0.06	31	7.5	150	--	20	<5
28-Jan-86	08	0	1.6	15.4	4.5	153	1.0	14.0	0.62	0.20	0.06	0.03	32	7.5	140	--	20	<5
09-Apr-86	01	0	7.6	12.4	4.8	133	1.0	11.0	0.27	0.10	0.02	0.03	30	1.5	130	1.6	<20	<10
09-Apr-86	01	7	5.7	4.3	5.9	749	N.D.	44.0	0.70	<0.10	0.60	0.03	62	15.0	410	--	--	--
09-Apr-86	02	0	7.6	13.2	5.6	129	1.0	11.0	0.25	0.10	<0.02	0.03	29	3.0	110	--	460	<10
09-Apr-86	03	0	6.2	12.0	4.8	94	N.D.	8.0	0.24	0.10	0.02	0.04	17	2.0	120	--	<20	<10
09-Apr-86	04	0	4.1	13.5	4.6	88	N.D.	7.0	0.25	<0.10	0.03	0.04	17	2.0	110	--	<20	<10
09-Apr-86	05	0	3.8	13.5	3.8	92	N.D.	9.0	0.24	0.10	<0.02	0.04	15	4.5	96	--	<20	<10
09-Apr-86	06	0	5.6	13.1	5.5	116	1.0	10.0	0.26	0.20	0.02	0.03	24	3.0	110	--	200	10
09-Apr-86	07	0	7.0	13.2	5.5	128	1.0	9.0	0.22	0.20	0.17	0.03	28	4.0	110	--	<20	<10
09-Apr-86	08	0	7.3	13.1	5.0	127	1.0	11.0	0.29	0.10	0.19	0.04	29	5.0	160	--	20	<10
28-May-86	01	0	21.3	9.6	6.1	146	5.0	14.0	1.00	<0.10	<0.02	0.04	32	1.0	88	2.8	--	10
28-May-86	01	7	6.4	4.0	6.2	785	3.0	14.0	0.98	0.40	0.07	0.04	32	1.5	90	--	--	--
28-May-86	02	0	21.6	9.4	5.6	145	2.0	15.0	0.98	<0.10	<0.02	0.04	32	1.5	94	--	--	<10
28-May-86	03	0	21.4	9.2	5.8	115	2.0	14.0	0.98	<0.10	0.02	0.06	24	4.0	94	--	--	10
28-May-86	05	0	21.4	9.2	5.8	115	--	--	--	--	--	--	--	--	--	--	--	--
28-May-86	06	0	21.2	7.4	5.9	124	4.0	15.0	0.91	0.40	0.49	0.07	25	3.0	84	--	--	10
28-May-86	07	0	21.0	9.3	5.8	145	2.0	15.0	0.90	<0.10	0.02	0.07	32	0.5	92	--	--	<10
28-May-86	08	0	20.2	8.9	5.8	144	3.0	15.0	1.00	<0.10	0.09	0.04	32	1.0	96	--	--	50

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
11-Jun-86	01	0	19.1	9.5	5.8	135	3.0	13.0	0.52	<0.10	0.06	0.04	30	3.5	100	1.8	--	<10
11-Jun-86	01	7	6.5	4.0	5.9	648	1.4	40.0	1.20	0.10	0.66	0.04	30	2.5	430	--	--	--
11-Jun-86	02	0	19.4	9.3	5.5	137	2.0	13.0	0.57	<0.10	0.07	0.03	20	4.0	96	--	--	<10
11-Jun-86	03	0	16.6	9.3	5.1	104	1.0	12.0	0.46	0.10	0.04	0.06	26	3.0	110	--	--	50
11-Jun-86	06	0	16.4	9.4	5.5	124	2.0	13.0	0.49	0.10	0.03	0.05	30	1.5	96	--	--	10
11-Jun-86	07	0	19.5	9.2	5.9	136	2.0	14.0	0.46	0.10	0.04	0.04	29	3.5	94	--	--	<10
11-Jun-86	08	0	19.2	8.8	5.5	137	2.0	14.0	0.55	<0.10	0.05	0.04	29	9.0	100	--	--	<10
24-Jun-86	01	0	21.2	9.1	5.2	139	3.0	15.0	0.57	0.20	0.14	0.03	27	2.5	80	1.8	--	10
24-Jun-86	01	7	6.7	5.1	6.0	782	3.7	87.0	1.80	--	1.10	0.04	60	8.0	600	--	--	--
24-Jun-86	02	0	21.8	9.2	5.1	138	2.0	16.0	0.48	0.10	0.03	0.03	27	1.5	78	--	--	10
24-Jun-86	03	0	19.6	8.6	5.1	136	3.0	9.0	0.70	0.20	0.06	0.06	28	4.0	98	--	--	10
24-Jun-86	06	0	20.1	7.9	5.1	137	2.0	10.0	0.54	0.10	0.02	0.03	26	3.5	82	--	--	10
24-Jun-86	07	0	21.4	8.9	5.1	138	3.0	13.0	0.52	0.10	0.05	0.05	28	2.5	72	--	--	<10
24-Jun-86	08	0	20.6	8.4	5.2	138	3.0	15.0	0.67	0.10	0.11	0.06	27	2.5	82	--	--	<10
09-Jul-86	01	0	24.8	7.9	5.5	120	2.0	13.0	0.36	--	0.10	0.04	27	0.5	90	1.8	--	<5
09-Jul-86	01	7	7.1	3.4	5.7	675	34.0	39.0	1.00	<0.10	0.90	0.05	--	2.5	520	--	--	--
09-Jul-86	02	0	25.4	8.0	5.4	121	2.0	12.0	0.60	<0.10	0.50	0.03	27	N.D.	78	--	--	5
09-Jul-86	03	0	24.5	8.9	5.1	119	2.0	12.0	0.64	<0.10	0.07	0.08	27	5.0	110	--	--	<5
09-Jul-86	06	0	23.5	6.4	4.9	99	4.0	11.0	0.56	<0.10	0.10	0.08	23	3.0	110	--	--	20
09-Jul-86	07	0	24.5	8.2	5.2	120	2.0	12.0	0.36	--	0.15	0.04	27	3.0	88	--	--	5
09-Jul-86	08	0	23.4	7.3	5.2	119	3.0	14.0	0.32	.10	0.20	0.05	27	3.0	88	--	--	10
23-Jul-86	01	0	24.5	7.8	6.4	132	3.0	14.0	0.75	<0.10	0.20	0.04	26	N.D.	86	2.0	--	--
23-Jul-86	01	7	7.2	4.0	6.0	673	10.0	36.0	1.30	<0.10	0.50	0.04	68	1.0	290	--	--	--
23-Jul-86	02	0	24.0	8.0	6.2	113	2.0	19.0	0.65	<0.10	0.05	0.03	26	N.D.	74	--	--	--
23-Jul-86	03	0	24.0	8.5	6.6	145	4.0	16.0	0.91	<0.10	0.10	0.08	31	8.0	120	--	--	--
23-Jul-86	06	0	22.8	6.5	6.3	135	N.D.	16.0	0.75	<0.10	0.20	0.04	26	0.5	96	--	--	--
23-Jul-86	07	0	23.3	8.0	6.2	130	3.0	15.0	0.54	<0.10	0.05	0.03	26	0.5	96	--	--	--
23-Jul-86	08	0	21.6	7.4	6.2	129	5.0	15.0	0.63	<0.10	0.05	0.04	25	0.5	92	--	--	--
04-Aug-86	01	0	24.0	7.8	5.5	129	4.0	13.0	1.10	<0.10	<0.02	0.03	25	1.0	72	1.6	--	--
04-Aug-86	01	7	7.3	3.4	6.1	705	41.0	57.0	2.80	<0.10	1.20	0.05	45	6.5	560	--	--	--
04-Aug-86	02	0	23.2	8.4	5.7	128	3.0	13.0	0.91	<0.10	<0.02	0.02	25	1.5	76	--	--	--
04-Aug-86	03	0	23.5	8.7	5.0	97	3.0	6.0	0.64	<0.10	<0.02	0.09	19	7.0	82	--	--	--
04-Aug-86	06	0	24.0	7.1	5.8	125	4.0	13.0	0.69	<0.10	<0.02	0.06	23	5.0	88	--	--	--
04-Aug-86	07	0	23.5	8.2	6.0	127	3.0	13.0	0.39	<0.10	<0.02	0.04	25	1.5	76	--	--	--
04-Aug-86	08	0	21.9	7.9	5.8	126	3.0	13.0	0.44	<0.10	<0.02	0.04	25	4.5	76	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
20-Aug-86	01	0	22.1	7.7	5.2	113	3.0	20.0	0.14	<0.10	0.10	0.03	23	N.D.	66	1.1	--	--
20-Aug-86	01	7	7.5	3.4	5.9	660	12.0	44.0	0.62	<0.10	0.50	0.02	67	2.5	290	--	--	--
20-Aug-86	02	0	22.8	7.2	5.6	114	4.0	20.0	0.10	<0.10	0.04	0.02	22	N.D.	58	--	--	--
20-Aug-86	03	0	20.1	8.2	5.1	102	1.0	14.0	0.22	<0.10	0.10	0.05	17	5.5	78	--	--	--
20-Aug-86	04	0	16.8	8.5	4.4	67	N.D.	8.0	0.18	<0.10	0.04	0.04	12	0.5	66	--	--	--
20-Aug-86	05	0	16.7	8.6	4.1	92	N.D.	13.0	0.20	0.20	0.10	0.04	13	1.0	90	--	--	--
20-Aug-86	06	0	19.5	6.9	5.3	97	3.0	17.0	0.28	<0.10	0.04	0.06	17	0.5	82	--	--	--
20-Aug-86	07	0	21.9	8.3	5.7	113	3.0	19.0	0.25	<0.10	0.04	0.03	21	1.0	64	--	--	--
20-Aug-86	08	0	21.2	8.1	5.8	112	3.0	18.0	0.23	0.50	0.10	0.04	22	2.5	82	--	--	--
09-Sep-86	01	0	17.2	9.0	5.9	116	4.0	15.0	0.37	<0.10	0.02	0.03	22	2.0	80	--	--	--
09-Sep-86	01	7	7.5	5.0	6.1	606	3.0	16.0	0.30	<0.10	0.02	0.03	23	2.0	86	--	--	--
09-Sep-86	02	0	17.9	9.1	6.1	113	3.0	15.0	0.30	<0.10	<0.02	0.10	21	2.0	84	--	--	--
09-Sep-86	03	0	12.5	8.4	6.1	112	5.0	16.0	0.48	0.10	0.13	0.07	25	2.5	100	--	--	--
09-Sep-86	04	0	8.2	10.9	5.4	101	1.0	13.0	0.29	0.30	<0.02	0.06	16	N.D.	110	--	--	--
09-Sep-86	05	0	12.8	9.8	5.3	70	1.0	7.0	0.41	0.10	0.02	0.05	16	N.D.	76	--	--	--
09-Sep-86	06	0	16.2	8.0	6.3	124	3.0	17.0	0.51	0.10	0.03	0.05	22	0.5	94	--	--	--
09-Sep-86	07	0	15.9	9.9	6.1	113	3.0	17.0	0.30	<0.10	0.02	0.02	22	1.0	92	--	--	--
09-Sep-86	08	0	14.3	9.7	6.1	113	4.0	16.0	0.20	<0.10	0.06	0.05	22	N.D.	92	--	--	--
29-Sep-86	01	0	15.8	9.4	5.4	121	3.0	16.0	0.56	0.10	0.05	0.04	24	5.0	90	2.4	--	--
29-Sep-86	01	7	6.5	3.6	6.4	679	21.0	49.0	1.70	--	1.10	0.08	45	62.0	530	--	--	--
29-Sep-86	02	0	16.1	9.2	5.8	123	3.0	16.0	0.61	<0.10	<0.02	0.05	24	6.5	74	--	--	--
29-Sep-86	03	0	15.2	8.7	5.4	118	3.0	12.0	0.64	0.20	0.03	0.07	22	5.0	92	--	--	--
29-Sep-86	06	0	15.7	8.2	5.4	126	2.0	15.0	0.65	<0.10	<0.02	0.03	24	4.5	90	--	--	--
29-Sep-86	07	0	16.1	9.5	5.5	121	2.0	15.0	0.50	<0.10	0.03	0.02	24	4.5	96	--	--	--
29-Sep-86	08	0	15.5	8.3	5.8	120	4.0	18.0	0.57	<0.10	0.09	0.02	23	4.5	94	--	--	--
28-Oct-86	01	0	9.5	12.6	4.8	155	4.0	7.0	0.62	<0.10	0.04	0.02	30	1.5	100	1.4	--	--
28-Oct-86	01	7	7.7	5.0	6.4	675	59.0	49.0	2.00	--	1.10	0.04	45	8.0	580	--	--	--
28-Oct-86	02	0	9.5	12.4	4.8	152	2.0	20.0	0.60	<0.10	0.03	0.02	30	1.0	88	1.9	--	--
28-Oct-86	03	0	10.5	11.3	5.1	99	3.0	14.0	0.62	<0.10	<0.02	0.07	19	1.0	100	--	--	--
28-Oct-86	06	0	8.5	12.1	5.1	99	3.0	22.0	0.55	<0.10	<0.02	0.04	18	0.5	90	--	--	--
28-Oct-86	07	0	9.8	13.0	4.9	147	2.0	30.0	0.46	<0.10	0.02	0.02	28	0.5	92	--	--	--
28-Oct-86	08	0	9.6	11.8	4.9	145	2.0	29.0	0.52	<0.10	0.02	0.02	28	0.5	94	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
25-Nov-86	01	0	2.6	14.1	4.4	168	5.0	15.0	1.00	0.10	0.08	<0.02	31	3.0	110	0.9	--	--
25-Nov-86	01	7	6.5	4.4	5.9	608	26.0	34.0	2.10	--	0.96	0.05	45	21.0	364	--	--	--
25-Nov-86	02	0	2.7	13.8	4.4	167	3.0	7.0	0.92	0.10	0.08	<0.02	31	6.0	108	--	--	--
25-Nov-86	03	0	2.6	13.9	4.0	86	N.D.	10.0	0.82	0.10	<0.02	<0.02	12	N.D.	66	--	--	--
25-Nov-86	04	0	2.4	14.1	3.9	93	N.D.	13.0	0.70	0.10	<0.02	<0.02	13	1.0	86	--	--	--
25-Nov-86	05	0	2.6	14.1	4.1	76	N.D.	16.0	0.84	0.20	<0.02	<0.02	13	4.0	76	--	--	--
25-Nov-86	06	0	3.0	13.8	4.6	111	2.0	16.0	0.77	0.20	<0.02	<0.02	21	1.0	94	--	--	--
25-Nov-86	07	0	2.2	15.5	4.4	165	1.0	21.0	0.76	0.10	0.07	<0.02	30	7.0	128	--	--	--
25-Nov-86	08	0	2.4	13.9	4.3	164	1.0	6.0	0.62	0.10	0.06	<0.02	30	10.0	104	--	--	--
29-Dec-86	01	0	0.0	13.9	4.8	136	3.0	14.0	0.37	0.30	0.07	0.06	26	N.D.	88	1.2	--	--
29-Dec-86	01	7	5.2	3.8	6.2	638	1.0	21.0	0.31	0.20	0.10	0.06	56	2.5	146	--	--	--
29-Dec-86	02	0	0.2	13.5	5.0	128	1.0	15.0	0.30	0.20	0.06	0.04	25	0.5	78	1.2	--	--
29-Dec-86	03	0	0.1	14.0	4.2	102	N.D.	12.0	0.26	0.20	<0.02	0.03	15	1.5	58	--	--	--
29-Dec-86	04	0	0.1	12.9	4.2	102	N.D.	13.0	0.31	0.20	<0.02	0.04	15	N.D.	62	--	--	--
29-Dec-86	05	0	0.4	13.6	4.2	103	N.D.	8.0	0.26	0.10	0.03	0.04	19	1.5	60	--	--	--
29-Dec-86	06	0	1.0	13.7	4.8	122	1.0	22.0	0.27	0.20	<0.02	0.03	22	N.D.	74	--	--	--
29-Dec-86	07	0	2.1	13.8	4.6	140	1.0	26.0	0.28	0.10	0.11	0.03	29	1.0	80	--	--	--
29-Dec-86	08	0	2.2	13.9	4.8	139	1.0	15.0	0.27	0.20	0.03	0.02	28	1.0	94	--	--	--
02-Feb-87	01	0	0.1	13.5	5.4	142	2.0	12.0	0.24	0.20	0.04	0.05	31	2.0	82	0.8	--	--
02-Feb-87	01	7	6.0	2.6	6.5	733	17.0	40.0	10.00	--	0.95	1.80	54	10.0	330	--	--	--
02-Feb-87	02	0	0.3	13.5	6.0	154	2.0	11.0	0.33	0.20	0.04	0.05	32	2.5	92	0.8	--	--
02-Feb-87	03	0	0.2	12.9	4.8	96	1.0	10.0	0.28	0.20	0.03	0.02	16	3.0	78	--	--	--
02-Feb-87	06	0	0.5	13.1	5.8	136	2.0	12.0	0.27	0.20	0.04	0.02	28	2.0	94	--	--	--
02-Feb-87	07	0	0.8	13.5	5.4	146	N.D.	15.0	0.25	0.20	0.06	<0.02	31	3.0	98	--	--	--
02-Feb-87	08	0	1.3	13.5	5.9	144	N.D.	15.0	0.19	0.20	0.06	0.04	32	9.0	110	--	--	--
23-Feb-87	01	0	0.2	11.8	5.0	166	3.0	14.0	0.69	0.30	0.05	0.08	35	2.5	120	0.8	--	--
23-Feb-87	01	7	5.5	2.0	5.9	675	8.0	27.0	1.70	0.10	0.45	0.07	56	6.5	230	--	--	--
23-Feb-87	02	0	0.0	12.3	5.0	160	3.0	10.0	1.20	0.20	0.05	0.05	34	2.0	100	0.8	--	--
23-Feb-87	03	0	0.1	13.0	4.7	110	1.0	10.0	0.86	0.20	<0.02	0.04	18	3.5	66	--	--	--
23-Feb-87	06	0	0.1	13.2	5.1	157	4.0	7.0	0.59	0.20	0.03	0.04	35	4.0	110	--	--	--
23-Feb-87	07	0	0.4	14.2	5.1	159	3.0	15.0	0.57	20	0.05	0.04	35	6.0	100	--	--	--
23-Feb-87	08	0	0.6	13.6	4.9	150	3.0	15.0	0.89	0.20	0.06	0.09	34	2.0	98	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
19-Mar-87	01	0	0.0	13.5	5.3	172	4.0	18.0	0.31	0.40	0.06	0.05	36	3.0	100	--	--	--
19-Mar-87	01	7	5.2	2.4	6.1	655	10.0	47.0	1.20	<0.10	0.93	0.03	58	9.5	400	--	--	--
19-Mar-87	02	0	0.1	13.5	5.3	168	2.0	14.0	0.51	0.30	0.06	0.04	37	6.0	110	--	--	--
19-Mar-87	03	0	0.5	13.5	4.6	94	N.D.	8.0	0.26	0.10	<0.02	0.03	18	2.0	70	--	--	--
19-Mar-87	06	0	1.0	13.7	5.4	198	3.0	19.0	0.24	0.30	0.04	0.02	45	4.0	120	--	--	--
19-Mar-87	07	0	1.1	13.5	4.9	180	2.0	10.0	0.24	0.20	0.06	0.02	40	2.0	110	--	--	--
19-Mar-87	08	0	1.9	13.8	5.2	178	3.0	10.0	0.24	0.20	0.05	0.02	40	3.0	110	--	--	--
12-May-87	01	0	16.4	10.1	6.5	125	4.0	14.0	0.67	0.20	<0.02	0.03	26	2.0	86	1.4	--	<5
12-May-87	01	7	5.8	7.3	2.1	140	N.D.	16.0	0.49	0.20	0.09	0.03	26	3.5	96	--	--	--
12-May-87	02	0	16.5	10.3	7.1	124	3.0	9.0	0.61	0.20	<0.02	0.03	24	1.0	80	--	--	<5
12-May-87	03	0	16.1	7.8	5.4	125	3.0	14.0	0.61	0.20	<0.02	0.04	25	2.5	90	--	--	<5
12-May-87	04	0	11.0	9.8	4.1	98	N.D.	10.0	0.49	0.20	<0.02	0.03	16	0.5	60	--	--	<5
12-May-87	05	0	10.7	7.9	3.8	99	N.D.	5.0	0.60	0.10	<0.02	0.05	19	1.5	72	--	--	<5
12-May-87	06	0	13.8	7.8	5.7	127	N.D.	8.0	0.75	0.20	0.03	0.05	26	2.0	86	--	--	<5
12-May-87	07	0	16.5	10.2	6.7	123	3.0	12.0	0.50	0.20	<0.02	0.03	25	3.0	74	--	--	<5
12-May-87	08	0	16.4	9.4	6.6	121	3.0	11.0	0.87	0.10	<0.02	0.04	24	1.5	68	--	--	<5
04-Aug-87	01	0	24.0	7.5	6.4	140	4.0	17.0	1.00	0.10	0.07	0.21	27	N.D.	58	1.2	--	--
04-Aug-87	01	7	7.4	2.3	4.5	182	5.0	16.0	1.00	0.10	0.30	0.20	26	3.5	72	--	--	--
04-Aug-87	02	0	26.2	7.1	6.3	142	4.0	13.0	0.92	0.10	0.06	0.21	27	N.D.	88	--	--	--
04-Aug-87	03	0	27.5	7.3	6.3	132	5.0	14.0	1.20	0.10	<0.02	0.24	24	5.0	100	--	--	--
04-Aug-87	06	0	25.2	5.2	6.3	144	5.0	15.0	1.00	0.10	0.05	0.26	27	2.0	94	--	--	--
04-Aug-87	07	0	23.8	7.5	6.4	141	4.0	15.0	1.40	0.10	0.06	0.28	26	5.5	64	--	--	--
04-Aug-87	08	0	20.8	6.4	6.1	140	5.0	13.0	1.10	0.10	0.14	0.21	25	1.5	86	--	--	--
01-Oct-87	01	0	16.2	8.5	6.1	133	4.0	14.0	0.44	0.10	0.04	0.02	25	8.5	90	1.6	--	--
01-Oct-87	01	7	7.4	N.D.	6.9	329	8.0	13.0	0.78	<0.10	0.44	0.04	27	32.0	140	--	--	--
01-Oct-87	02	0	15.9	8.7	5.9	134	4.0	14.0	0.36	0.10	0.04	0.02	24	2.0	88	--	--	--
01-Oct-87	03	0	14.6	9.0	5.4	123	3.0	14.0	0.34	0.10	0.05	0.04	20	6.0	100	--	--	--
01-Oct-87	04	0	12.4	8.5	4.5	119	1.0	12.0	0.32	0.10	<0.02	0.04	15	0.5	98	--	--	--
01-Oct-87	05	0	12.7	8.3	4.3	126	N.D.	9.0	0.28	<0.10	0.02	0.03	22	4.0	92	--	--	--
01-Oct-87	06	0	14.8	7.1	5.4	131	3.0	13.0	0.30	0.10	0.03	0.02	23	2.5	88	--	--	--
01-Oct-87	07	0	15.8	8.9	5.9	133	4.0	14.0	0.34	0.10	0.04	0.02	24	3.0	98	--	--	--
01-Oct-87	08	0	15.2	7.8	5.8	132	4.0	14.0	0.38	0.10	0.06	0.02	24	1.5	110	--	--	--

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
26-Oct-87	01	0	9.6	10.0	5.5	134	3.0	25.0	0.86	0.10	0.04	0.03	24	2.0	96	1.8	--	--
26-Oct-87	01	7	7.5	1.3	6.7	307	24.0	33.0	2.20	--	0.78	0.05	24	10.0	290	--	--	--
26-Oct-87	02	0	9.1	9.9	5.5	133	4.0	24.0	0.84	0..10	0.04	0.04	24	N.D.	88	1.8	--	--
26-Oct-87	03	0	8.2	9.7	5.7	132	4.0	23.0	0.87	0.10	<0.02	0.10	24	2.0	100	--	--	--
26-Oct-87	04	0	5.9	10.3	4.8	120	4.0	20.0	1.00	0.10	<0.02	0.05	19	N.D.	92	--	--	--
26-Oct-87	05	0	8.0	9.8	4.5	106	1.0	14.0	1.00	<0.10	<0.02	0.05	19	1.0	76	--	--	--
26-Oct-87	06	0	9.0	9.7	5.6	136	4.0	27.0	1.00	0.10	0.03	0.06	24	1.0	92	--	--	--
26-Oct-87	07	0	8.3	10.6	5.5	132	4.0	27.0	0.69	0.10	0.03	0.04	24	0.5	88	--	--	--
26-Oct-87	08	0	7.9	9.8	5.7	130	3.0	24.0	0.70	0.10	0.03	0.03	24	0.5	94	--	--	--
25-Jan-88	01	0	1.6	13.6	5.6	156	2.0	24.0	0.38	0.20	0.05	0.03	30	0.5	110	--	--	--
25-Jan-88	01	7	2.9	8.8	5.1	390	3.0	26.0	0.50	0.20	0.07	0.04	80	0.5	200	--	--	--
25-Jan-88	02	0	0.4	13.5	5.9	134	1.0	18.0	0.64	0.20	0.03	0.04	22	0.5	92	--	--	--
25-Jan-88	03	0	0.4	13.0	5.4	123	1.0	16.0	0.42	0.20	<0.02	0.03	19	N.D.	88	--	--	--
25-Jan-88	06	0	0.7	13.0	5.3	163	1.0	19.0	0.56	0.20	<0.02	0.03	34	N.D.	110	--	--	--
25-Jan-88	07	0	2.3	12.5	5.1	149	2.0	20.0	0.36	0.20	0.03	0.05	27	0.5	96	--	--	--
25-Jan-88	08	0	2.3	11.8	5.7	150	2.0	21.0	0.28	0.20	0.03	0.03	27	0.5	100	--	--	--
21-Mar-88	03	0	0.3	14.0	6.2	108	2.0	14.0	0.44	0.20	0.02	0.04	29	0.5	90	--	--	--
21-Mar-88	04	0	0.0	13.5	5.9	145	1.0	17.0	0.48	0.20	0.04	0.04	29	0.5	84	--	--	--
21-Mar-88	05	0	0.3	13.8	5.8	100	1.0	9.0	0.42	0.10	<0.02	0.03	20	2.5	66	--	--	--
21-Mar-88	06	0	0.3	14.0	7.1	191	3.0	16.0	0.48	0.20	0.02	0.03	44	0.5	110	--	--	--
21-Mar-88	07	0	2.2	12.3	6.7	183	3.0	15.0	0.44	0.20	0.04	0.04	39	1.5	96	--	--	--
21-Mar-88	08	0	2.2	13.2	6.7	179	3.0	16.0	0.42	0.20	0.03	0.07	39	1.0	100	--	--	--
02-May-88	01	0	9.4	10.9	4.7	181	2.0	18.0	0.39	0.20	<0.02	0.03	38	<1.0	110	1.4	--	--
02-May-88	01	7	5.1	5.8	4.1	323	N.D.	25.0	0.42	0.20	0.22	0.02	79	2.0	200	--	--	--
02-May-88	02	0	9.8	12.6	4.2	184	1.0	18.0	0.29	0.20	<0.02	0.08	38	<1.0	90	--	--	--
02-May-88	03	0	7.5	10.2	4.9	132	3.0	17.0	0.30	0.20	<0.02	0.13	27	4.0	94	--	--	--
02-May-88	04	0	6.7	9.8	4.2	94	N.D.	9.0	0.29	0.10	<0.02	0.04	14	<1.0	58	--	--	--
02-May-88	05	0	6.2	9.8	4.1	114	N.D.	12.0	0.29	0.10	<0.02	0.14	15	<1.0	72	--	--	--
02-May-88	06	0	7.6	9.8	5.1	134	3.0	16.0	0.52	0.20	<0.02	0.03	24	2.5	100	--	--	--
02-May-88	07	0	9.8	10.6	4.7	183	2.0	17.0	0.40	0.20	<0.02	0.03	38	<1.0	110	--	--	--
02-May-88	08	0	9.7	10.2	5.0	170	N.D.	17.0	0.28	0.20	<0.02	0.02	38	<1.0	160	--	--	--
14-Jul-88	01	0	26.3	7.8	5.8	155	4.0	20.0	0.52	0.10	0.03	0.03	31	1.5	100	1.7	--	--
14-Jul-88	01	7	6.9	1.8	4.1	281	N.D.	25.0	0.61	0.10	0.27	0.04	54	3.0	160	--	--	--
14-Jul-88	02	0	27.3	8.2	5.7	154	3.0	19.0	0.51	<0.10	<0.02	0.03	31	1.0	100	--	--	--
14-Jul-88	03	0	24.2	7.5	5.5	158	5.0	19.0	0.98	<0.10	<0.02	0.06	29	9.5	130	--	--	<5
14-Jul-88	06	0	25.8	5.7	5.7	157	4.0	20.0	0.62	0.10	0.02	0.04	31	1.0	130	--	--	45
14-Jul-88	07	0	25.9	6.8	5.6	157	3.0	19.0	0.31	<0.10	0.02	0.05	31	3.5	130	--	--	<5

DATE	STATION	SAMPLE DEPTH	TEMP	DO	pH	SPEC. COND.	TOTAL ALK.	TOTAL HARD.	TKN	NITRATE	AMMONIA	TOTAL PHOSPHATE	CHLORIDE	SUSPENDED SOLIDS	TOTAL SOLIDS	SECCHI DISK	TOTAL COLIFORM	FECAL COLIFORM
13-Apr-89	01	0	6.2	13.0	5.4	247	--	--	--	--	--	--	--	--	--	1.6	--	--
13-Apr-89	01	7	4.4	2.3	5.0	587	--	--	--	--	--	--	--	--	--	--	--	--
13-Apr-89	02	0	7.7	13.0	5.6	247	--	--	--	--	--	--	--	--	--	--	--	--
13-Apr-89	06	0	6.6	14.0	5.3	246	--	--	--	--	--	--	--	--	--	--	--	--
13-Apr-89	07	0	7.5	12.5	5.6	250	--	--	--	--	--	--	--	--	--	--	--	--
01-Aug-89	01	0	24.1	6.8	5.5	138	22.0	15.0	0.55	0.06	<0.02	0.04	29	1.5	84	2.6	--	--
01-Aug-89	01	7	6.5	N.D.	5.4	421	--	22.0	0.71	0.08	0.31	0.03	89	--	--	--	--	--
01-Aug-89	02	0	23.7	8.0	5.6	139	22.0	14.0	0.47	0.03	<0.02	0.05	29	1.5	92	--	--	--
01-Aug-89	07	0	23.5	7.0	5.8	139	20.0	15.0	0.59	0.03	0.02	0.03	29	<1.0	82	--	--	--
18-Jul-91	01	0	26.8	7.6	6.1	125	2.6	17.0	--	0.07	0.02	<0.02	--	3.0	64	1.2	--	--
18-Jul-91	01	7	6.4	1.1	3.9	176	1.0	20.0	--	0.09	0.18	<0.02	--	1.0	78	--	--	--
18-Jul-91	03	0	29.9	9.4	6.4	140	3.2	19.0	--	<0.02	<0.02	0.05	--	6.0	80	--	--	--
18-Jul-91	06	0	28.7	7.0	6.0	127	2.8	15.0	--	0.05	<0.02	<0.02	--	2.0	70	--	--	--

APPENDIX VII

MONITORING PROGRAM DATABASE FOR STATION 1

AT

DUPONT POND

DATABASE FOR STATION 1 AT DUNN POND IN GARDNER, MASSACHUSETTS

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
23-Apr-85	0.0	13.7	10.4	3.8	213
23-Apr-85	1.0	13.7	10.3	3.9	214
23-Apr-85	2.0	9.9	10.7	3.9	219
23-Apr-85	3.0	8.1	10.8	3.8	220
23-Apr-85	4.0	7.6	10.6	3.8	223
23-Apr-85	5.0	7.0	10.4	3.8	227
23-Apr-85	6.0	6.4	5.2	3.3	444
23-Apr-85	7.0	6.4	4.5	3.3	461
07-May-85	0.0	12.9	9.2	3.8	208
07-May-85	1.0	12.2	9.2	3.9	207
07-May-85	2.0	12.0	9.2	3.9	207
07-May-85	3.0	11.0	9.2	3.8	213
07-May-85	4.0	8.0	8.8	3.6	228
07-May-85	5.0	6.8	7.5	3.6	260
07-May-85	6.0	6.6	0.7	3.1	500
07-May-85	7.0	6.6	N.D.	3.6	868
23-May-85	0.0	19.0	9.2	3.9	201
23-May-85	1.0	18.7	9.3	3.9	200
23-May-85	2.0	17.8	9.8	3.9	199
23-May-85	3.0	14.1	10.8	3.9	199
23-May-85	4.0	10.2	9.8	3.3	240
23-May-85	5.0	7.9	8.3	3.2	284
23-May-85	6.0	7.4	N.D.	2.9	598
23-May-85	7.0	7.0	N.D.	3.7	845
03-Jun-85	0.0	20.7	9.4	4.4	188
03-Jun-85	1.0	20.2	9.2	4.2	188
03-Jun-85	2.0	19.3	9.1	4.2	188
03-Jun-85	3.0	15.6	10.4	4.0	198
03-Jun-85	4.0	10.3	9.3	3.4	248
03-Jun-85	5.0	8.1	6.7	3.3	290
03-Jun-85	6.0	7.3	2.4	3.2	545
03-Jun-85	7.0	7.1	N.D.	4.0	810
19-Jun-85	0.0	19.6	8.4	--	184
19-Jun-85	1.0	18.6	8.1	--	183
19-Jun-85	2.0	18.2	7.8	--	182
19-Jun-85	3.0	16.2	7.6	--	161
19-Jun-85	4.0	12.8	6.4	--	248
19-Jun-85	5.0	8.8	4.7	--	295
19-Jun-85	6.0	7.8	0.7	--	590
19-Jun-85	7.0	7.2	N.D.	--	820

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
02-Jul-85	0.0	20.9	8.2	4.0	220
02-Jul-85	1.0	20.4	8.0	3.5	220
02-Jul-85	2.0	18.6	7.9	3.2	220
02-Jul-85	3.0	17.4	7.7	3.2	212
02-Jul-85	4.0	13.1	6.3	3.0	306
02-Jul-85	5.0	9.9	3.4	3.0	375
02-Jul-85	6.0	8.3	1.0	2.9	802
02-Jul-85	7.0	7.5	N.D.	2.8	972
15-Jul-85	0.0	23.6	7.6	4.2	221
15-Jul-85	1.0	23.4	7.4	4.0	221
15-Jul-85	2.0	23.4	7.4	3.9	224
15-Jul-85	3.0	21.2	7.0	3.8	204
15-Jul-85	4.0	15.5	6.8	--	291
15-Jul-85	5.0	11.4	4.2	--	415
15-Jul-85	6.0	9.6	1.0	--	743
15-Jul-85	6.5	8.5	0.3	--	965
30-Jul-85	0.0	24.7	8.3	4.9	189
30-Jul-85	1.0	23.9	8.2	4.8	187
30-Jul-85	2.0	23.8	8.1	4.7	188
30-Jul-85	3.0	23.3	7.4	4.8	173
30-Jul-85	4.0	17.9	8.7	4.6	276
30-Jul-85	5.0	12.5	7.2	3.9	336
30-Jul-85	6.0	10.5	4.5	3.5	727
30-Jul-85	7.0	8.8	4.2	5.2	855
13-Aug-85	0.0	24.4	7.5	4.8	176
13-Aug-85	1.0	24.0	7.5	4.8	176
13-Aug-85	2.0	23.7	7.3	4.6	176
13-Aug-85	3.0	23.2	6.0	5.2	172
13-Aug-85	4.0	18.3	6.1	4.1	284
13-Aug-85	5.0	13.1	4.3	3.6	358
13-Aug-85	6.0	10.5	1.6	3.6	721
13-Aug-85	7.0	9.0	1.4	3.6	885
04-Sep-85	0.0	19.8	8.1	4.6	146
04-Sep-85	1.0	19.2	7.9	4.5	146
04-Sep-85	2.0	18.8	7.7	4.5	160
04-Sep-85	3.0	18.3	7.2	4.4	159
04-Sep-85	4.0	17.4	6.5	4.5	167
04-Sep-85	5.0	13.8	3.7	3.6	377
04-Sep-85	6.0	12.1	2.1	3.5	560
04-Sep-85	7.0	9.8	1.7	4.8	720
23-Sep-85	0.0	18.6	9.0	4.6	172
23-Sep-85	1.0	18.7	8.7	4.5	172
23-Sep-85	2.0	18.7	8.7	4.5	172
23-Sep-85	3.0	17.3	8.6	4.4	173
23-Sep-85	4.0	16.4	7.1	4.2	190
23-Sep-85	5.0	14.1	4.2	3.5	378
23-Sep-85	6.0	11.2	1.7	3.5	618
23-Sep-85	7.0	9.4	1.7	3.5	871

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
21-Oct-85	0.0	12.1	8.0	3.3	165
21-Oct-85	1.0	11.5	7.6	2.9	168
21-Oct-85	2.0	11.4	7.6	2.9	168
21-Oct-85	3.0	11.3	7.6	2.9	168
21-Oct-85	4.0	11.3	7.6	3.0	167
21-Oct-85	5.0	11.2	7.3	2.9	180
21-Oct-85	6.0	10.9	0.2	2.9	590
21-Oct-85	7.0	9.5	N.D.	4.3	892
09-Apr-86	0.0	7.4	12.4	4.8	133
09-Apr-86	1.0	6.7	12.6	4.8	133
09-Apr-86	2.0	6.3	12.4	4.8	136
09-Apr-86	3.0	5.8	12.2	4.7	140
09-Apr-86	4.0	4.9	9.6	4.2	266
09-Apr-86	5.0	4.4	8.9	3.9	360
09-Apr-86	6.0	4.7	6.8	3.6	445
09-Apr-86	7.0	5.7	4.3	5.9	749
28-May-86	0.0	21.3	9.6	6.1	146
28-May-86	1.0	19.4	9.5	5.6	144
28-May-86	2.0	16.7	9.0	5.3	134
28-May-86	3.0	10.4	10.3	4.6	149
28-May-86	4.0	7.9	8.0	4.0	308
28-May-86	5.0	6.6	6.7	3.8	376
28-May-86	6.0	6.2	4.9	3.5	420
28-May-86	7.0	6.4	4.0	6.2	785
11-Jun-86	0.0	19.1	9.5	5.8	135
11-Jun-86	1.0	18.5	9.1	5.3	135
11-Jun-86	2.0	16.1	7.7	4.8	115
11-Jun-86	3.0	12.2	8.6	4.5	138
11-Jun-86	4.0	8.4	7.0	3.7	318
11-Jun-86	5.0	6.8	5.2	3.5	383
11-Jun-86	6.0	6.4	4.4	3.4	425
11-Jun-86	7.0	6.5	4.0	5.9	648
24-Jun-86	0.0	21.2	9.1	5.2	139
24-Jun-86	1.0	20.5	8.9	5.1	138
24-Jun-86	2.0	16.1	7.6	4.8	123
24-Jun-86	3.0	12.0	8.1	4.4	151
24-Jun-86	4.0	9.6	6.7	3.8	336
24-Jun-86	5.0	7.3	5.8	3.4	414
24-Jun-86	6.0	6.8	5.5	3.4	451
24-Jun-86	7.0	6.7	5.1	6.0	782
09-Jul-86	0.0	24.8	7.9	5.5	120
09-Jul-86	1.0	21.4	7.6	5.2	119
09-Jul-86	2.0	17.2	6.5	5.0	102
09-Jul-86	3.0	13.3	6.0	4.5	133
09-Jul-86	4.0	9.4	5.9	3.8	258
09-Jul-86	5.0	7.9	4.1	3.5	366
09-Jul-86	6.0	7.2	3.6	4.1	366
09-Jul-86	7.0	7.1	3.4	5.7	675

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
23-Jul-86	0.0	24.5	7.8	6.4	132
23-Jul-86	1.0	23.3	7.7	6.0	131
23-Jul-86	2.0	18.6	5.9	5.6	122
23-Jul-86	3.0	13.7	6.0	4.8	144
23-Jul-86	4.0	10.7	5.7	4.0	295
23-Jul-86	5.0	8.3	5.1	3.8	386
23-Jul-86	6.0	7.4	4.2	4.4	409
23-Jul-86	7.0	7.2	4.0	6.0	673
04-Aug-86	0.0	24.0	7.8	5.5	129
04-Aug-86	1.0	21.5	6.9	5.4	125
04-Aug-86	2.0	19.9	5.6	5.2	115
04-Aug-86	3.0	13.9	5.5	4.6	132
04-Aug-86	4.0	10.1	4.6	3.8	320
04-Aug-86	5.0	8.3	4.2	3.6	372
04-Aug-86	6.0	7.5	3.6	5.3	441
04-Aug-86	7.0	7.3	3.4	6.1	705
20-Aug-86	0.0	22.1	7.7	5.2	113
20-Aug-86	1.0	21.0	6.8	5.1	115
20-Aug-86	2.0	19.7	5.2	4.9	102
20-Aug-86	3.0	13.9	4.3	4.1	129
20-Aug-86	4.0	10.3	4.0	3.5	332
20-Aug-86	5.0	8.5	4.0	4.5	364
20-Aug-86	6.0	7.8	3.5	5.4	452
20-Aug-86	7.0	7.5	3.4	5.9	660
09-Sep-86	0.0	17.2	9.0	5.9	116
09-Sep-86	1.0	16.0	9.0	5.7	116
09-Sep-86	2.0	15.7	8.6	5.5	116
09-Sep-86	3.0	13.7	4.9	4.2	175
09-Sep-86	4.0	10.9	4.5	3.7	338
09-Sep-86	5.0	8.5	5.1	5.3	400
09-Sep-86	6.0	7.8	5.0	5.9	528
09-Sep-86	7.0	7.5	5.0	6.1	606
29-Sep-86	0.0	15.8	9.4	5.4	121
29-Sep-86	1.0	15.4	8.8	5.3	120
29-Sep-86	2.0	14.8	8.6	5.2	109
29-Sep-86	3.0	13.8	7.1	5.2	113
29-Sep-86	4.0	11.5	4.0	4.1	306
29-Sep-86	5.0	8.9	3.7	5.8	394
29-Sep-86	6.0	8.1	3.6	6.3	523
29-Sep-86	7.0	6.5	3.6	6.4	679
28-Oct-86	0.0	9.5	12.6	4.8	155
28-Oct-86	1.0	9.1	12.4	4.7	154
28-Oct-86	2.0	9.1	10.7	4.5	155
28-Oct-86	3.0	9.1	10.7	4.5	156
28-Oct-86	4.0	9.0	10.3	4.5	153
28-Oct-86	5.0	8.8	6.4	5.8	373
28-Oct-86	6.0	8.3	5.0	6.2	531
28-Oct-86	7.0	7.7	5.0	6.4	675

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
25-Nov-86	0.0	2.6	14.1	4.4	168
25-Nov-86	1.0	2.5	13.9	4.3	167
25-Nov-86	2.0	2.5	13.8	4.3	168
25-Nov-86	3.0	2.6	12.8	4.2	167
25-Nov-86	4.0	2.6	12.4	4.2	170
25-Nov-86	5.0	2.7	12.0	4.1	170
25-Nov-86	6.0	2.8	11.5	4.1	174
25-Nov-86	7.0	6.5	4.4	5.9	608
29-Dec-86	0.0	0.0	13.9	4.8	136
29-Dec-86	1.0	2.0	13.9	4.6	147
29-Dec-86	2.0	2.2	13.3	4.5	160
29-Dec-86	3.0	2.6	12.6	4.4	178
29-Dec-86	4.0	2.7	12.1	4.4	200
29-Dec-86	5.0	3.0	11.3	4.3	221
29-Dec-86	6.0	3.2	10.3	3.9	249
29-Dec-86	7.0	5.2	3.8	3.8	638
02-Feb-87	0.0	0.1	13.5	5.4	142
02-Feb-87	1.0	1.3	13.3	4.8	150
02-Feb-87	2.0	2.5	11.3	4.5	165
02-Feb-87	3.0	3.4	10.6	4.3	183
02-Feb-87	4.0	3.5	10.0	4.1	204
02-Feb-87	5.0	3.5	10.0	4.1	243
02-Feb-87	6.0	5.5	3.2	5.9	683
02-Feb-87	7.0	6.0	2.6	6.5	733
23-Feb-87	0.0	0.2	11.8	5.0	166
23-Feb-87	1.0	0.9	11.1	4.8	170
23-Feb-87	2.0	2.6	9.5	4.3	171
23-Feb-87	3.0	3.4	7.9	4.2	182
23-Feb-87	4.0	3.4	9.0	4.1	212
23-Feb-87	5.0	3.6	8.4	4.0	248
23-Feb-87	6.0	4.6	3.5	3.4	342
23-Feb-87	7.0	5.5	2.0	5.9	675
19-Mar-87	0.0	0.0	13.5	5.3	172
19-Mar-87	1.0	1.4	12.9	5.3	192
19-Mar-87	2.0	2.9	11.7	4.8	201
19-Mar-87	3.0	3.2	9.8	4.6	219
19-Mar-87	4.0	3.0	10.0	4.7	262
19-Mar-87	5.0	3.3	9.3	4.6	299
19-Mar-87	6.0	4.0	6.3	3.9	375
19-Mar-87	7.0	5.2	2.4	6.1	655
12-May-87	0.0	16.4	10.1	6.5	125
12-May-87	1.0	16.3	9.8	5.7	125
12-May-87	2.0	10.9	9.8	4.7	121
12-May-87	3.0	8.4	9.8	4.0	120
12-May-87	4.0	6.7	9.3	3.2	126
12-May-87	5.0	6.1	8.1	2.4	134
12-May-87	6.0	6.0	7.5	2.3	140
12-May-87	7.0	5.8	7.3	2.1	140

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
04-Aug-87	0.0	24.0	7.5	6.4	140
04-Aug-87	1.0	22.8	7.4	6.3	140
04-Aug-87	2.0	22.0	4.9	6.0	139
04-Aug-87	3.0	14.8	4.1	5.5	134
04-Aug-87	4.0	10.0	4.5	5.0	153
04-Aug-87	5.0	8.0	3.0	4.7	170
04-Aug-87	6.0	7.7	2.4	4.5	178
04-Aug-87	7.0	7.4	2.3	4.5	182
01-Oct-87	0.0	16.2	8.5	6.1	133
01-Oct-87	1.0	16.1	8.8	6.0	133
01-Oct-87	2.0	14.4	7.9	5.8	134
01-Oct-87	3.0	13.8	7.4	5.7	134
01-Oct-87	4.0	11.0	1.3	4.4	163
01-Oct-87	5.0	8.9	0.8	4.3	181
01-Oct-87	6.0	7.9	N.D.	5.6	185
01-Oct-87	7.0	7.4	N.D.	6.9	329
26-Oct-87	0.0	9.6	10.0	5.5	134
26-Oct-87	1.0	9.5	9.5	5.4	134
26-Oct-87	2.0	9.4	9.2	5.4	134
26-Oct-87	3.0	9.2	9.1	5.4	134
26-Oct-87	4.0	9.1	8.6	5.3	134
2[illegible]-Oct-87	5.0	8.9	7.6	5.0	142
26-Oct-87	6.0	8.[illegible]	4.3	4.9	179
26-Oct-87	7.0	7.5	1.3	6.7	307
25-Jan-88	0.0	1.6	13.6	5.6	156
25-Jan-88	1.0	3.1	11.0	5.2	153
25-Jan-88	2.0	3.4	10.4	5.1	161
25-Jan-88	3.0	3.4	9.3	5.1	186
25-Jan-88	4.0	3.4	9.3	5.3	225
25-Jan-88	5.0	3.6	8.2	5.0	264
25-Jan-88	6.0	2.9	7.7	5.1	340
25-Jan-88	7.0	2.9	8.8	5.1	390
02-May-88	0.0	9.4	10.9	4.7	181
02-May-88	1.0	9.3	10.5	4.8	181
02-May-88	2.0	9.4	10.4	4.8	181
02-May-88	3.0	8.3	10.2	4.7	160
02-May-88	4.0	7.9	9.9	4.7	175
02-May-88	5.0	7.0	9.6	4.7	211
02-May-88	6.0	6.0	7.7	4.4	296
02-May-88	7.0	5.1	5.8	4.1	323
14-Jul-88	0.0	26.3	7.8	5.8	155
14-Jul-88	1.0	25.5	7.5	5.8	155
14-Jul-88	2.0	21.4	6.8	5.7	155
14-Jul-88	3.0	14.5	6.3	5.1	153
14-Jul-88	4.0	10.6	5.2	4.5	208
14-Jul-88	5.0	7.8	3.9	4.3	240
14-Jul-88	6.0	7.3	2.8	4.2	267
14-Jul-88	7.0	6.9	1.8	4.1	281

DATE	SAMPLE DEPTH (Meters)	TEMP. (C.)	DISSOLVED OXYGEN (mg/l)	pH (S. U.)	SPECIFIC COND. (umhos)
13-Apr-89	0.0	6.2	13.0	5.4	247
13-Apr-89	1.0	6.1	12.4	5.2	247
13-Apr-89	2.0	6.1	11.9	5.1	248
13-Apr-89	3.0	6.1	11.6	5.0	248
13-Apr-89	4.0	5.6	11.4	5.0	245
13-Apr-89	5.0	4.8	9.4	4.8	272
13-Apr-89	6.0	4.3	4.0	4.6	598
13-Apr-89	7.0	4.4	2.3	5.0	587
01-Aug-89	0.0	24.1	6.8	5.5	138
01-Aug-89	1.0	23.3	--	5.1	141
01-Aug-89	2.0	18.1	--	4.4	129
01-Aug-89	3.0	11.6	--	4.1	184
01-Aug-89	4.0	9.0	--	4.0	249
01-Aug-89	5.0	7.5	--	3.9	333
01-Aug-89	6.0	6.8	--	3.8	371
01-Aug-89	7.0	6.5	N.D.	5.4	421
18-Jul-91	0.0	26.8	7.6	6.1	125
18-Jul-91	1.0	23.1	7.8	5.9	125
18-Jul-91	1.5	20.0	3.0	5.3	--
18-Jul-91	2.0	17.0	0.7	4.7	119
18-Jul-91	2.5	13.7	2.8	4.7	--
18-Jul-91	3.0	11.2	3.7	4.3	142
18-Jul-91	4.0	8.5	3.3	4.0	162
18-Jul-91	5.0	7.2	2.5	3.9	169
18-Jul-91	6.0	6.7	2.0	3.8	173
18-Jul-91	7.0	6.4	1.1	3.9	176

APPENDIX VIII

MAPS OF PERCENT COVER BY MACROPHYTES

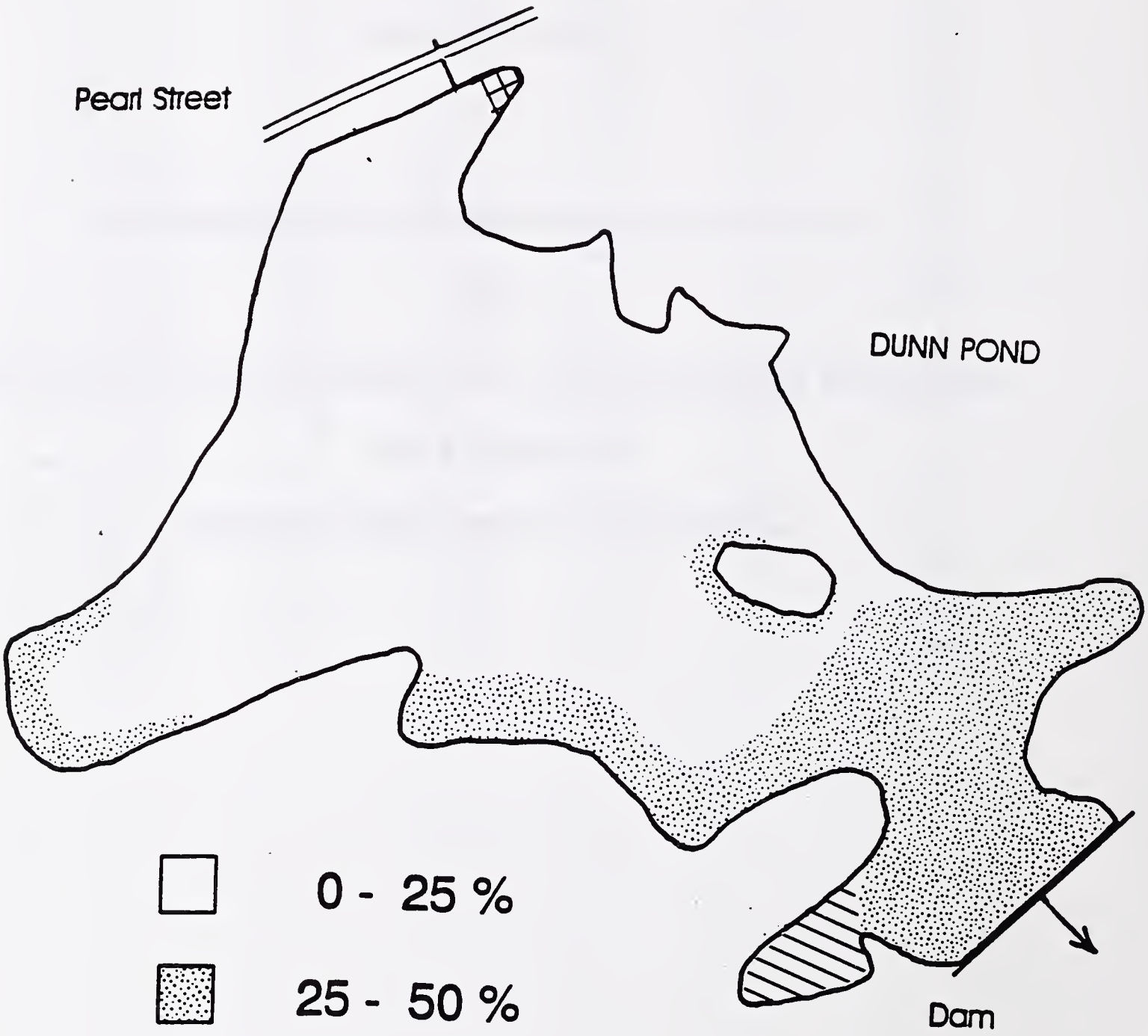
AND

TABULATED FREQUENCY OF OCCURRENCE OF MACROPHYTES

AT DUNN POND

SUBSEQUENT TO ITS RESTORATION

PERCENT COVER BY MACROPHYTES FOLLOWING RESTORATION. AUGUST 13, 1985



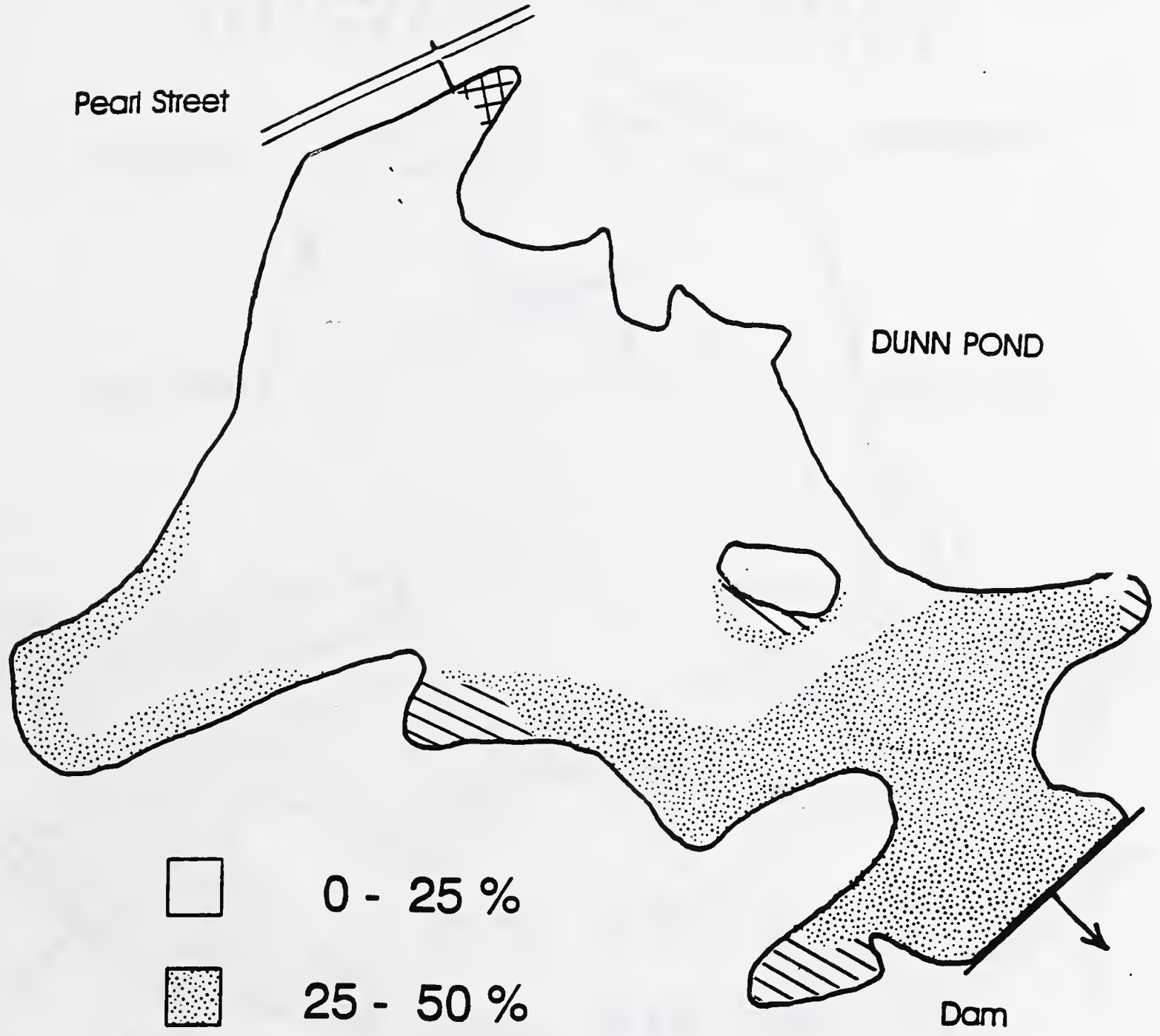
0 - 25 %

25 - 50 %

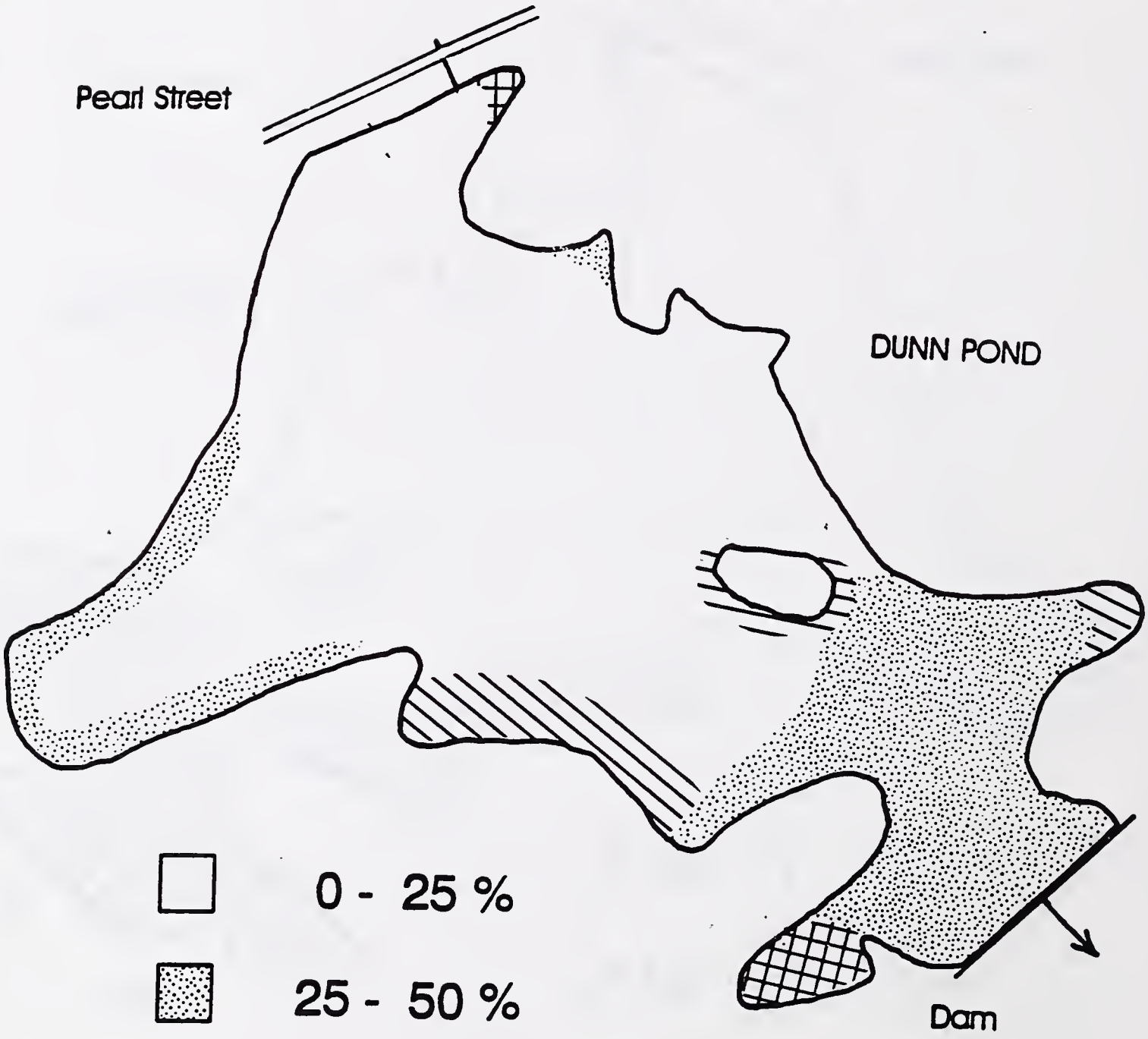
50 - 75 %

75 - 100 %

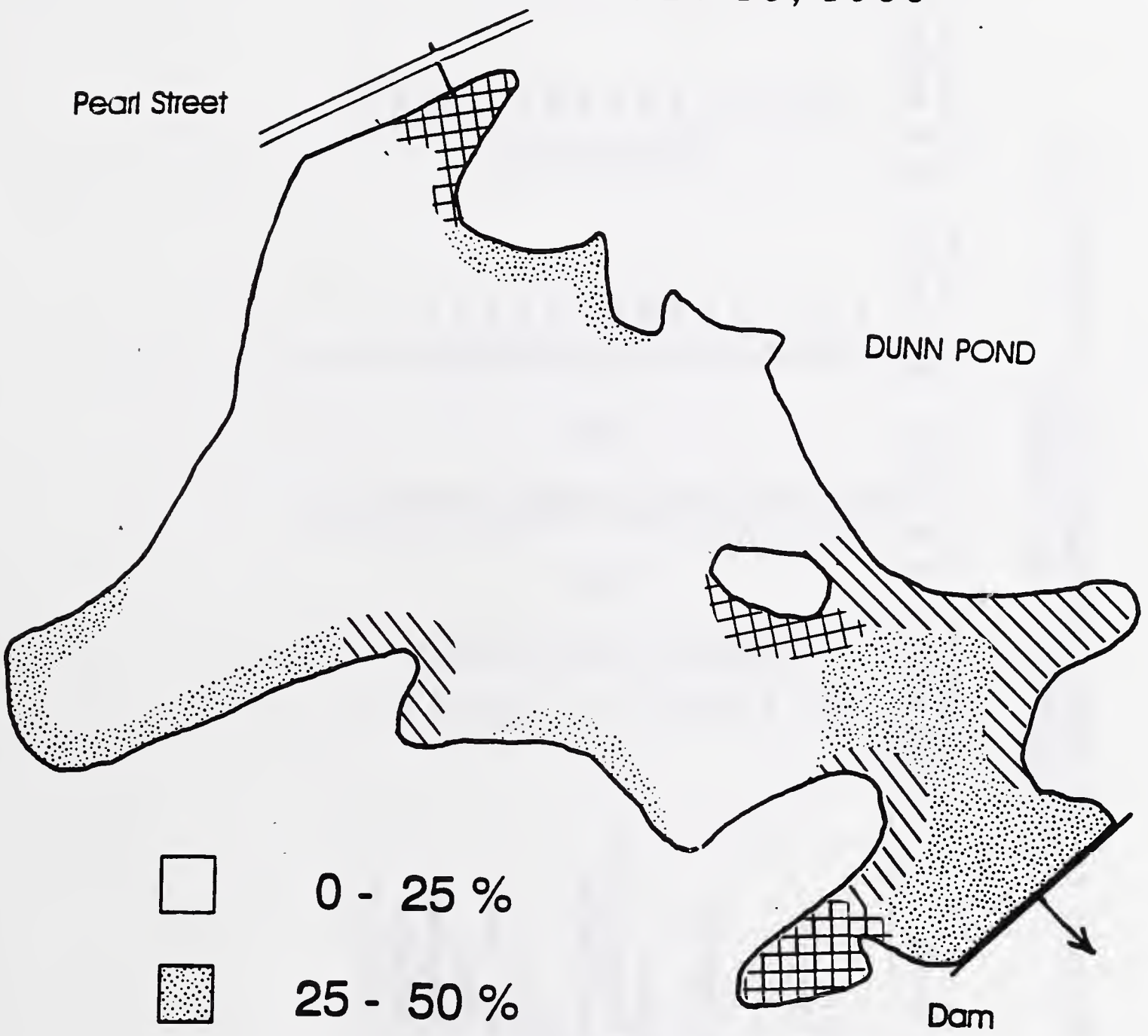
PERCENT COVER BY MACROPHYTES FOLLOWING RESTORATION. AUGUST 20, 1986



PERCENT COVER BY MACROPHYTES FOLLOWING RESTORATION. JULY 23, 1987



PERCENT COVER BY MACROPHYTES FOLLOWING RESTORATION. JULY 15, 1988



FREQUENCY OF OCCURRENCE OF MACROPHYTES AT DUNN POND
IN GARDNER, MASSACHUSETTS

PLANT NAME	13-Aug-85 (% @ N=35)	20-Aug-86 (% @ N=30)	23-Jul-87 (% @ N=35)	15-Jul-88 (% @ N=35)	18-Jul-91 (% @ N=30)
Carex sp.	--	--	--	--	7
Eleocharis sp.	24	13	9	11	10
Filamentous algae	48	--	--	20	--
Juncus sp.	--	17	6	--	--
Ludwigia sp.	21	--	--	6	--
Myriophyllum humile	60	50	69	91	57
Nuphar sp.	15	--	--	--	--
Nuphar variegata	--	33	26	14	50
Potamogeton bicupulatus	63	57	60	71	47
Potamogeton epihydrus	--	3	6	6	17
Sparganium sp.	--	40	17	26	20
Typha latifolia	6	--	--	3	3
Valisneria americana	45	--	--	--	--
Utricularia gibba	--	--	--	--	50
Utricularia purpurea	--	--	--	--	40
Utricularia radiata	54	7	--	66	10
Utricularia vulgaris	--	--	--	--	20

APPENDIX IX

U. S. EPA MEMORANDUM: ELIGIBILITY

OF

DAM RECONSTRUCTION ACTIVITIES

FOR

CLEAN LAKES FUNDING

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE APR 16 1980

SUBJECT The Eligibility of Dam Reconstruction Activities for Clean Lakes Funding

FROM Joseph Krivak, Acting Director
Criteria and Standards Division (WH-585)

TO Water Division Directors

ATTN: Clean Lakes Coordinators

RECEIVED-EPA
APR 23 1980
WATER QUALITY BRANCH

CLEAN LAKES PM 80-4

I. Purpose

The purpose of this memorandum is to inform the Regions of the criteria and policy which will be used to determine: (1) dam safety and the need for repairs and (2) the 314 funding eligibility of dam modification, and/or construction activities.

II. Policy

The majority of clean lake projects do not involve dam structures. There have been only a few cases where proposed clean lakes projects have involved dam safety questions. However, it would be very embarrassing to the Agency if a dam failure occurred on an active clean lakes project. To avoid this possibility, the appropriate State agency must be consulted on any proposed clean lakes project involving dam activities. This agency is the State agency designated with dam inspection responsibility appropriate to Public Law 92-367. The U.S. Army Corps of Engineers issued regulations (ER 1110-2-106) and guidance (Appendix D of ER 1110-2-106) for use by States to meet dam inspection requirements. A dam safety inspection by the State is mandatory and the applicant is required to submit the results of this inspection as part of the application. The State report on the necessity of any dam repair activities, a description of the required repairs, and the estimated repairs costs will be required. All required dam safety repairs must be completed or there must be an agreement that they will be completed, including a schedule, before a Phase II grant is awarded. Dam repairs whose primary purpose is dam safety will not be eligible for 314 funding. This process should eliminate any unforseen dam safety problems arising during the implementation of a project.

Dam construction and/or modification activities associated with clean lakes projects must be an integral part of the most cost-effective lake restoration scheme before 314 monies can be awarded to fund these activities. Dam reconstruction activities must have as their primary purpose the restoring of water quality of the lake. Dam reconstruction activities for a water quality purpose will generally be limited to not more than $250,000 of 314 funds per project. An example of dam modification activity which would be eligible for 314 funding follows:

If increased seasonal water level fluctutation (i.e. drawdown was the approved lake restoration activity, the maximum funding for reconstruction activities such as outlet modifications and dam gate repairs would be $500,000 ($250,000 in Clean Lakes Program funds and $250,000 in other funds).

Dam inspection requirements should not place an undue burden on either the States' authorized dam inspection agency and/or the clean lakes agency since it is unlikely that more than 2 or 3 applications will ever require dam safety inspections within any given State.

APPENDIX X

MITIGATION OF EXCESS SUSPENDED SOLIDS DISCHARGED TO FOSTER BROOK DURING EXCAVATION OF DUNN POND

Mark A. Goldstein
Director

City Hall · · · Room 210
Tel. 632-3412

CITY OF GARDNER

DEPARTMENT OF COMMUNITY DEVELOPMENT AND PLANNING

Gardner, Massachusetts 01440

MEETING AT DUNN POND/PARK APRIL 4, 1984

ATTENDANCE:

Charles Swanson - Storch Associates
Carlos Carranza - Bay State Environmental
Duncan Burns - Chairman, Conservation Commission
Peter Sabettini - Conservation Commission
Joe Zenga - Pacella Brothers
Mike Ackerman - DEQE
Rick Pavoni - DEM

PROPOSED MITIGATION MEASURES:

1. Excavate forebay settling pond approximately 4' deep.
2. Construct coarse rock berm filter.
3. Repair silt fences - carry shore to shore.
4. Place check dams in the channel (2) - coarse rock.
5. Cover exposed surfaces of grey clay to extent possible.
6. Armor the sump excavation pit.
7. Limit dredging to peat area instead of clay.
8. Shut down durring storms.
9. Prepare for contingency plan - chemical treatment -
    1. Test soils - size, clay content
    2. Polymer tests

Mark A. Goldstein
Director

City Hall · · · Room 210
Tel. 632-3412

CITY OF GARDNER

DEPARTMENT OF COMMUNITY DEVELOPMENT AND PLANNING

Gardner, Massachusetts 01440

April 23, 1984

Mr. Duncan H. Burns, Jr., Chairman
Conservation Commission
Room 112, City Hall
Gardner, Massachusetts 01440

RE: File 160-50, Dunn Pond Restoration Project

Mr. Burns,

With respect to Condition #14 of the recently extended Order of Conditions, the Department of Community Development and Planning respectfully requests your review and inclusion of the attached plans and design specifications as an amendment to the original plans and design specifications for this file. These additional plans and design specifications are a result of our recent field meetings which involved appropriate siltation mitigation measures. The approved mitigation measures will allow this important project to continue on schedule.

The Department additionally requests formal notification of the Commission's review and inclusion of the attached plans and design specifications so that the construction contractor can resume this project in a timely fashion.

During all future dredging at the site, the Resident Engineer will be monitoring the turbidity of the water leaving the site to ascertain whether it is acceptable, as stated in the design specifications. You will be notified in writing by the Resident Engineer should the turbidity reach levels above those specified. These notifications are intended to both make you aware of any water quality problems on the site and to solicit your input into what steps will be necessary to bring the turbidity back to acceptable levels. Site visits to review ongoing siltation mitigation measures; particularly during periods of high turbidity is strongly urged.

If this office may be of any further assistance in clarifying any aspect of this project, please do not hesitate to contact us.

Sincerely,

Mark Goldstein, Director

cc: Mayor Charles P. McKean
Pacella Brothers, Incorporated
Michael Ackerman, DEQE
Charles Swanson, Storch Associates
Arthur Young, City Engineer
Rick Pavoni, Resident Engineer

Charles P. McKean
Mayor

City Hall - - - Room 1
Tel. 632-1900

Executive Department, City of Gardner

Gardner, Massachusetts 01440

Received
Mass. Div. of
APR 25 1984
Water Pollution Control
Westboro, MA

April 24, 1984

Pacella Brothers, Incorporated
3 Madison Street
Plainville, Massachusetts 02762

ATTN: Mr. Michael Pacella

RE: Site Improvements at Dunn Park and Restoration of Dunn Pond
Gardner Heritage State Park

Dear Mr. Pacella:

This letter is to formalize in writing the Verbal Agreement reached between Pacella Brothers, Incorporated and the City of Gardner at the meeting held April 19, 1984 in Room 209, Gardner City Hall. Attending the meeting were:

Michael Pacella	Pacella Brothers
Joe Zenga	Pacella Brothers
Charles Swanson	Storch Associates
Carlos Carranza	Bay State Environmental
Michael Ackerman	DWPC
Arthur Young	City Engineer, Gardner
Mark Goldstein	City Planner, Gardner
Rick Pavoni	DEM

The meeting was called in response to Pacella's letter of April 11, 1984 to address concerns stemming from the shutdown of the project on April 3rd and 4th, 1984 due to the high siltation downstream and the subsequent "Proposed Mitigation Measures" developed as the result of a meeting on April 4, 1984 with representatives of the Gardner Conservation Commission. (Copies attached).

The agreement between Pacella Brothers, Incorporated and the City of Gardner based on the items listed in the above mentioned letter from Pacella is as follows:

(A) The contract time will be extended by seven (7) calendar days from 280 calendar days to 287 calendar days. (Original contract time of 270 days plus 10 day extension approved March 7, 1984). The new completion date is September 11, 1984. The contractor stated that he feels confident at this time that the project can be completed by this new completion date. Increase contract price for the shutdown of April 3rd and 4th, 1984. The increased cost is for the equipment on the job that was idled for two days shutdown. The daily equipment costs are based on rental rates from the latest edition of "Rental Rate Blue Book".

The following is a breakdown of the daily cost of equipment:

FMC LS-7400A Backhoe	$2,246.00	
CAT 988 B Loader	1,399.00	
CAT 966 Loader	853.00	
65 kw Generator-Diesel Powered	100.00	
6" Electric Submersible Pump	187.00	
50 Ft. 6" Discharge Hose With Couplings	27.00	
Office Trailer	8.00	
Utilities, etc.	18.00	
3 Ten Wheelers at $140/Each	420.00	
	$5,258.00	PER DAY
Total For 2 Days		$10,516.00
65 kw Generator 5 Days at $100/Day		500.00
	TOTAL	$11,016.00

(B) Item 8 "Shutdown during storms" of the Proposed Mitigation Measures was meant as a suggestion to the contractor to help keep the turbidity of discharge water from Dunn Pond within the limit of 50 JTU as specified in Section 2G Paragraph 2G.02(2) of the specifications. Pursuant to this Section of the specifications (and Article 12 of the Gardner Conservation Commission's Order of Conditions), the Resident Engineer will take daily samples and readings of the discharge from Dunn Pond. The contractor and the Gardner Conservation Commission will be notified immediately, in writing, when the readings exceed 50 JTU. The contractor will be responsible to take corrective action and to inform the Gardner Conservation Commission with regard to the problem and corrective action(s) the contractor is taking and/or purpose to take.

(C) Reference is made to Proposed Mitigation Measures:

(1) The contractor will excavate a forebay settling pond as per the attached sketch (Storch: Dunn Pond 4/20/84) and replace the excavated material before the completion of the project. It is understood that the contractor will cast the excavated material around the perimeter of the excavated forebay and not be required to truck the material to a storage site. The excavation and replacing of material will be paid for under pay item 2D-2 Dredging and Disposal of Material at the City Landfill at $2.50 per C.Y.

(2) The contractor will construct a coarse rock berm filter as per the attached sketch (Storch: Dunn Pond 4/20/84) and remove same by rough grading the material. The constructing and removal of the berm will be paid for under pay item 2E-4 and 2G-3 at $10 per ton.

(3) This is part of the original contract.

(4) The contractor will construct and remove coarse rock check dam under pay item 2E-4 and 2G-3 at $10 per ton.

(D) The contractor is to conduct his operations pursuant to Article III Paragraph 10 of the specifications and meet the requirements of Section 2G Paragraph 2G.02(2). Proposed Mitigation Measures 5, 6, 7, and 8 are suggestions and not directives to meet the requirements of this paragraph. There will be no additional costs to the City of Gardner or time extension to the contract time due to the request of this paragraph.

The City of Gardner assures that sufficient funds are available to meet additional costs of the magnitude agreed upon in this letter.

Sincerely yours,

Charles P. McKean
Mayor

Enclosure: Two (2) - Please sign both copies and return one copy to Mayor

cc: Michael Ackerman, DEQE
Charles Swanson, Storch Associates
Rick Pavoni, DEM
Mark Goldstein, City Planner
Arthur Young, City Engineer
Carlos Carranza, Bay State Environmental

4/24/84

CITY OF GARDNER
CHARLES P. MC KEAN
MAYOR

DATE:

PACELLA BROTHERS, INCORPORATED
MICHAEL PACELLA

DATE:

CPM:vjk

AND 2 DISPOSE ALL
EBRIS, INCLUDING BRUSH,
STUMPS AND MISCELLANEOUS
BELOW THE NORMAL WATERLINE (EL. 1103.5)
= ORGANIC BOTTOM SEDIMENTS TO A
I DEPTH 2' AS DIRECTED BY THE
K.

575.60 N 27

110

110

110

18

MH
RIM
1104.83
Inv = 1091.40

T.S. 1120.5
B.S. 1117.0

T.S. 1114.0
B.S. 1111.5

T.S. 1111.0
B.S. 1108.5

105

200'±

Pond

150'±

EXIST. SEWER
PROTECTED FR
(SEE SPECS)

Sedimentation Pond
4'± Deep

PILOT
B-15
ELEV= 1098.8

105

100

105

Prop Rock
Berm Filter

Silt Fence in
5' Baffle Pattern

5' Typ.

PILOT

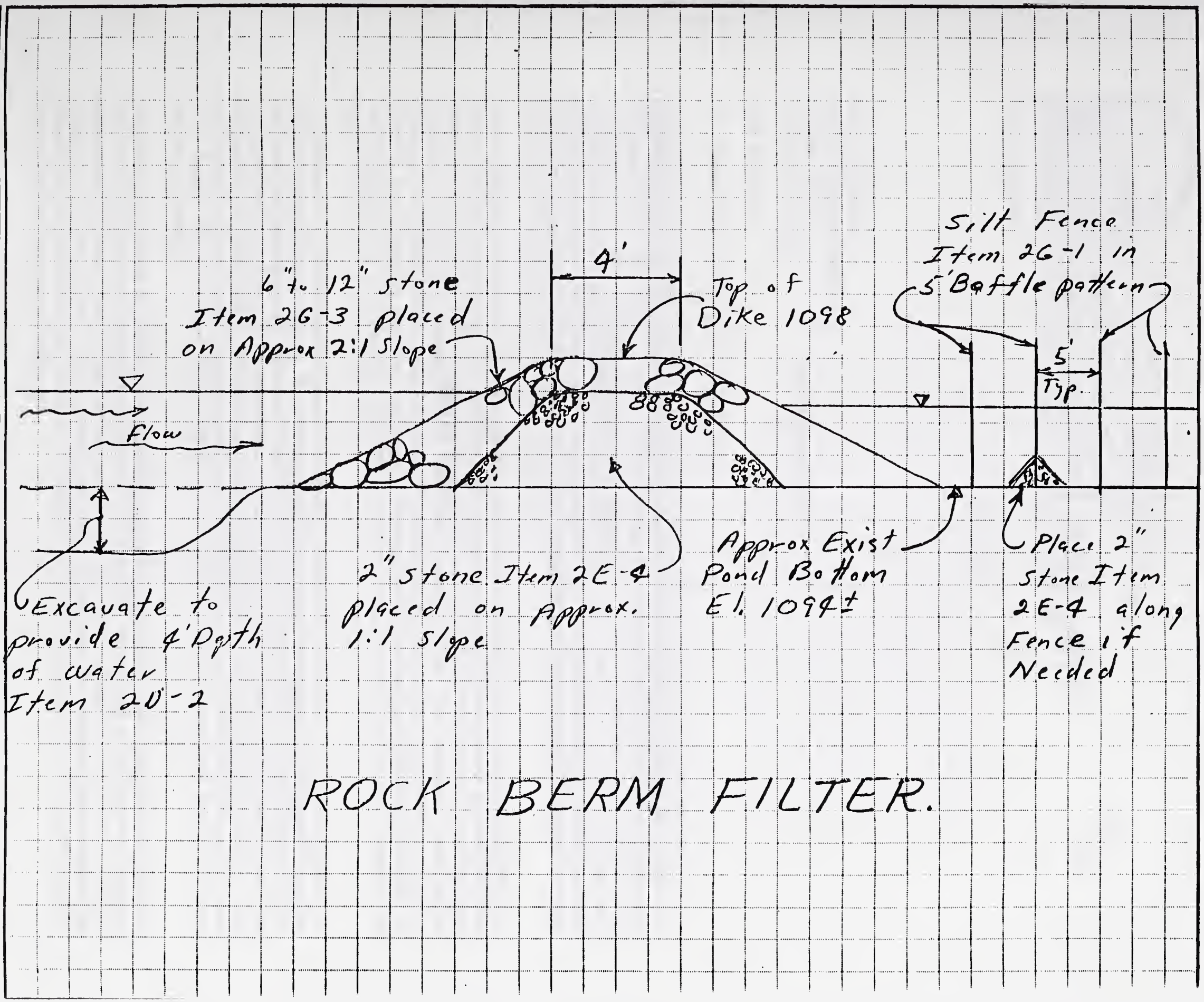
SHEET NO. _____ OF _____

CALCULATED BY CWS DATE 4/20/84

CHECKED BY _____ DATE _____

SCALE _____

STORCH ENGINEERS/STORCH ASSOCIATES
Engineers - Landscape Architects - Planners
Architects - Environmental Consultants



ROCK BERM FILTER.

APPENDIX XI

CORRESPONDENCE WITH DOROTHY ZUG, SUPERINTENDENT

DUNN STATE PARK

INCLUDING RECOMMENDATIONS FOR MANAGING STUMP POND

AND

DUNN POND

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection
Water Pollution Control Technical Services

Daniel S. Greenbaum
Commissioner

DEC 1991

August 13, 1991

Dorothy Zug
Senior Supervisor
Gardner Heritage State Park
26 Lake Street
Gardner, MA 01440

Dear Ms. Zug:

RE: **Phase II Restoration of Dunn Pond**

As you know, Dr. Richard McVoy and I surveyed Dunn Pond/Stump Pond on July 18, 1991 to develop a final evaluation of this restoration project based on selected biological, chemical, and physical criteria. Our evaluation will be included in a report that I am writing for the U.S. Environmental Protection Agency, as required, since that agency funded one-half of the $1.26 Million restoration project (ponds only). Although there can be little doubt that this restoration project was a complete success, Dr. McVoy and I are disturbed by the lack of post-restoration maintenance that was evident at the two ponds, especially Stump Pond. Proper and timely maintenance of the Stump Pond facility is essential to assure long-term protection of the existing water quality in Dunn Pond.

I have addressed this letter to you per our telephone discussion since it is my understanding that the Department of Environmental Management (DEM) has assumed de facto management of the entire Dunn Pond park facility, including Stump Pond. It is my understanding further that title to the Dunn Pond park property will eventually be transferred from the city of Gardner to DEM. Thus, you should know that the city agreed to "operate and maintain the facilities" funded under this restoration project when the Mayor, Solicitor, and Treasurer executed a Substate Agreement with the Commonwealth's Department of Environmental Quality Engineering (subsequently renamed Department of Environmental Protection) on August 26, 1983.

Dr. McVoy and I observed several major maintenance problems at the Stump Pond site (please refer to enclosed map and photographs). First among these is the large accumulation of sediments where the storm drains discharge at both corners of the filter dike. In fact, one-half of the 30 inch drain pipe at the southeast "corner" of Stump Pond is obstructed with sand, grit, et cetera. This problem is indicative of poor maintenance of catch basins in the storm drain systems along Pearl Street and Betty Spring Road. The accumulated sediments need to be excavated from Stump Pond soon, and the 30 inch drain pipe may need to be flushed with pressurized water. All excavated material needs to be removed from the site and disposed of properly.

Related to the problem described above is the displacement of some rock slabs in the center of the filter dike (refer to photograph), probably due to erosion. These slabs were placed at this location to support excavation equipment, which would be used to repair the dike itself or, possibly, to remove accumulated sediments from Stump Pond. This problem needs to be rectified soon since further displacement of the stone slabs may render the dike unsafe for excavation equipment. Also, the stone slabs probably serve as a spillway during severe rainstorms.

76 North Drive • Westborough, MA 01581-3334 • FAX 508-792-7479 • Telephone 508-792-7470

It is also likely that the filter dike itself has not been inspected or maintained since its 1985 construction date. If so, this acts to defeat the purpose of converting Stump Pond into a settling basin and filter that reduces the load of suspended solids and nutrients to Dunn Pond. I solicited a set of recommendations for inspecting and maintaining the filter dike for your benefit, and Carlos Carranza of Baystate Environmental Consultants, Inc. kindly provided the enclosed Recommendations for Filter Dike Maintenance Procedures following his search of archived files on the Dunn Pond/Stump Pond restoration project.

At Dunn Pond Dr. McVoy and I observed erosion, particularly at the extreme northeast "corner" proximal to Pearl Street (refer to enclosed map and photograph). There are several deep gullies evident at that location and a sand bar extends to 10-15 feet from the original shoreline. Gullies are also evident at the northwest "corner" of Dunn Pond; stormwater runoff from the gravel parking lot and Pearl Street are the likely causes of this erosion. Although the services of an engineer will likely be required to design plans for erosion control at both of these sites, remedial measures (e.g., hay bale/silt screen barriers) should be instituted soon to avoid further damage.

It is my recommendation that the Department of Environmental Management (DEM) develop a Dunn Pond/Stump Pond water quality management plan that encompasses routine inspection and maintenance of the aforementioned facilities. Although adoption of any such plan may need to await formal transfer of title of these properties to DEM, a memorandum of understanding might be executed between DEM and the city of Gardner as an interim measure so that the problems that I have identified in this letter are not exacerbated in the meantime. I can offer some help to you, but I must temper that offer by acknowledging that I am not an engineer and by stating that DEP/DWPC's Clean Lakes Program was an early victim of the state fiscal crisis, consequently my time would need to be limited.

If you have any questions about this letter or the enclosures, please telephone me at (508) 366-9181 (Note: the Technical Services Branch office is scheduled to close soon; at that time my telephone number will change to (617) 292-5673). Also, may I please have the favor of your written response to this letter.

Sincerely,

Robert C. Haynes

Robert C. Haynes, Ph.D.
Limnology Section

Enclosures
RH/p
cc: Charles J. Manca, Mayor of Gardner
B. Donahoe, Director, DWPC
R. Isaac
R. McVoy
W. Howard, US EPA
N. O'Leary, Director, DEP Central Regional Office

BEC

RECOMMENDATIONS FOR FILTER DIKE MAINTENANCE PROCEDURES

1. On a daily basis, record staff gage levels to the nearest one tenth of a foot (estimate to nearest hundreth of foot).

2. Calculate the difference in staff gage readings and record.

3. Visually observe conditions on the upstream face of the filter dike, the downstream side of the dike and the riser pipe, specifically look for;

    a. Any obstruction at riser pipe (i.e. wood, brush, etc.).

    b. Any gullying or erosion on the dike.

    c. Any build up of algal slime on the upstream face, especially if related to an abnormal difference in staff gage readings (note: algal slimes often yield "fishy" odors, especially if exposed)

    d. Any water leakage around the dike, especially if related to gullying or storm damage.

4. Visually inspect water quality on the downstream side of the filter dike. It should be quite clear, especially when compared to upstream water clarity. If this is not the case inspect the upstream filter dike for possible plugging by fine sediments and/or algal slimes.

5. If filter dike plugging is suspected, or if it becomes feasible to annually renew the upstream sand filter, the following procedures are recommended.

    a. for minor coatings of algal, iron oxide, or sediment hand scraping with a rake should suffice in order to reactivate the filter face for adsorption raking should be possible from a small flat bottomed boat or from the dike fact. As a last resort, pumping of Stump Pond (rather than lowering of Dunn's Pond) should be evaluated. Pumped water should be passed through an armored hay bale or a temporary stone filter prior to passage into Dunn's Pond.

b. Should it become necessary to replace most of the one foot upstream sand face, drawdown of Stump Pond will probably be necessary followed by raking and removal of the spent sand. Replacement sand should be coarse sand (1-2 mm. diameter) free from fines and mica. Ordinary concrete sand (not mason's sand) or coarse beach sand should be more than adequate. The sand should be hand placed and manually tamped in a moist (not saturated) condition prior to allowing Stump Pond to rise.

c. As an intermediate step between a and b, raking and localized seasonal chlorination of Stump Pond water adjacent to the upstream dike face could be attempted. Downstream chlorine residuals as measured by test (DPD Test, Hach Chemical Co., Model CN-70 Cat. No. 14542-00 see order blank) should be kept close to zero. The introduction of the chlorine as a hypochlorate solution should be done manually adjacent to the upstream face, taking care to evenly disperse and mix the material.

6. The filter dike faces shall be kept free of vegetative growth utilizing manual removal methods. No herbicides or pesticides should be utilized.

Haynes

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

DIVISION OF FORESTS AND PARKS - REGION III
P. O. BOX 155, CLINTON, MA 01510 508-368-0126 FAX 368-0217

November 30, 1993

William F. Weld
GOVERNOR

Argeo Paul Cellucci
LT. GOVERNOR

Trudy Coxe
SECRETARY

Peter C. Webber
COMMISSIONER

Robert Haynes, Ph.D.
Department of Environmental Protection
Division of Water Pollution Control
1 Winter Street
Boston, MA 02108

Dear Bob:

I write in response to your request to describe the use of Dunn Pond. First, I will put Dunn Pond in its context of the Heritage Park systen, then, its use as part of Dunn Park.

Gardner Heritage State Park is part of a system of nine urban Heritage State Parks across Massachusetts located in urban centers. Each Heritage Park has a visitor center with an exhibit celebrating the history of the city. Several, including Gardner, have a recreational component. Part of the mission of the Heritage Parks is to bring recreational experiences to urban areas. In the city of Gardner the Heritage Park consists of a downtown Visitor Center housing major exhibit telling the story of the Chair City of the World. Dunn Park is its recreational component. Both facilities are viewed as making major positive contributions to the quality of life in the city and the surrounding region. Local realtors bring their clients to Dunn Park when they want to show them what recreational facilities the region has to offer.

Dunn Park, the recreational component, is used largely by people from the greater Gardner region and is appreciated for its beauty, the lovely building and the various recreational opportunities available. Attendance figures reflect the park's growing popularity. Attendance was 14,892 in FY '87 when the park was reopened and swimming was first available; it was 33,577 in FY '90 and grew to 48,964 in FY '93. Throughout the year people come to fish, use the lovely pond trail and to enjoy the playground equipment. In the summer they also come to swim and picnic. More recently, people have come for programs. In the winter we clear the pond for skating, and it is the only pond in Gardner presently cleared. The building is open Saturday afternoons and evenings and Sunday afternoons with a fire going and hot chocolate available. The three tall lights flood most of the pond with light in the evening.

printed on recycled paper

Skating during times when the building was open drew 2,248 people last winter with 500 coming for an evening ice skating party which featured toasting marshmallos on a fire by the pond. An Ice Fishing Derby draws 600 - 1,000 people, depending on the weather. We plan Native American Day for the spring, and in the summer there are Friday night campfires on a knoll overlooking the pond which have an average attendance of 70. We have a Children's Day, a Park Birthday Concert and a Labor Day Concert that 1,000 people enjoyed last year. Fall brings the Lumberjack Festival that features fancy log cutting, speed cutting and log rolling.

In summary, Dunn Park is well appreciated and well used by the region's residents, and the pond is an essential element of the park. Without prejudice, I can say Dunn Park is a premier recreational facility in the Commonwealth.

Sincerely yours,

Dorothy Zug
Park Superintendent

cc: Don Stoddard, Regional Supervisor
Carroll Holmes, Regional Supervisor